InfraTech: The New Frontier of Infrastructure Investment

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LTI/A
Long-term Infrastructure Investors Association

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Foreword

Faced by unprecedented global challenges – from climate change and rapid urbanisation to resource scarcity and geopolitical tensions – the infrastructure asset class stands at a critical juncture. Decisions taken today about the infrastructure underpinning our societies will reverberate for generations to come.

In this context, InfraTech – the convergence of infrastructure and cutting-edge technology – emerges as a beacon of hope, as a powerful tool for transformative change.

By harnessing artificial intelligence, the Internet of Things, blockchain, and other advanced technologies, InfraTech offers innovative solutions that can significantly enhance the efficiency, sustainability, resilience, longevity, and inclusiveness of our infrastructure and built environment. Be it smart cities that optimise resource consumption to climate-resilient infrastructure that can withstand extreme weather events, InfraTech's potential appears limitless.

But its promise extends far beyond mere technological advancement. As a matter of fact, InfraTech is akin to a paradigm shift in infrastructure development, one that aligns with the United Nations' Sustainable Development Goals and our societies' collective aspirations for a more equitable, sustainable world. Indeed, as it can enable a more efficient use of resources by reducing carbon emissions and improving access to essential services, InfraTech can play a pivotal role in addressing climate change and ushering in socioeconomic development.

However, InfraTech remains in its relative infancy, and is faced with a substantial financing gap. This is why a collaborative approach that brings together the strengths of both the public and private sectors is needed. Public-private partnerships are one essential element through which the gap between innovation and implementation can be bridged, as it combines the scale and regulatory power of the public sector with the expertise and agility of the private sector.

This report seeks to highlight the state of the current InfraTech ecosystem by thoroughly mapping the InfraTech funding landscape and the main sectoral trends and applications to infrastructure projects. It aims to review and analyse these trends and their implications for institutional investors, both sector-wise and in terms of business models and allocation strategies. An LTIIA working group was specifically set up to hold regular meetings and share several case studies from March to July 2024, drawing as much as possible on concrete experience and feedback from institutional investors to identify takeaways, provide guidance and, when appropriate, table proposals and recommendations to policymakers and infrastructure players.

As you delve into the pages of this report, we invite you to envision a future where InfraTech is the norm in cities' energy systems, transportation networks and other key infrastructure, with the hopes that this contributes to promoting a wider adoption of InfraTech solutions coupled with more investment flows. Harnessing the power of InfraTech to bring forth the resilient and sustainable infrastructure that we need has never been so urgent.

Vincent Levita
Chair, LTIIA

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Executive Summary

The infrastructure sector has been a laggard when it comes to the adoption of technology and advanced digital tools. Technology-enabled solutions are often not proactively integrated into infrastructure planning considerations nor considered critical to a project's success or to attracting private sector investments.

Infrastructure technology – or 'InfraTech' – has the potential to change this state of affairs across all segments of the infrastructure sector.

From artificial intelligence (AI), unmanned aerial vehicles/ drones, virtual reality/augmented reality tools and cloud computing, to sensors and the Internet of Things, to name a few, InfraTech solutions impact the development, delivery, and operation of infrastructure assets.

Considering and adopting InfraTech solutions is becoming a necessity for infrastructure players. As a matter of fact, InfraTech can enhance the climate resilience of infrastructure assets and enable a more efficient use of resources, all while attracting and mobilising private capital and hence helping bridge the infrastructure investment gap.

By thoroughly mapping the InfraTech funding landscape, reviewing the main sectoral trends, highlighting applications to infrastructure projects and their implications for institutional investors in terms of business models and allocation strategies, this report seeks to highlight the state and potential of the current InfraTech ecosystem. Ultimately, it seeks to foster awareness and understanding of the issues, obstacles, and opportunities in the infrastructure asset class to help catalyse and increase private investments in InfraTech projects and assets.

InfraTech deals, investors and lifecycle

Although InfraTech is still a relatively novel asset segment, it has rapidly come to occupy an important position in investment portfolios, and the private sector has been the primary source of InfraTech funding, a trend largely attributed to the predominant role played by asset managers. Given the growth of data centres and the anticipated demand for and rollout of AI solutions in various sectors in the coming years, InfraTech is expected to further grow.

Out of 55,989 InfraTech deals made across the world since 2015, a little under two-thirds (63%) disclosed information. These deals are made up of 10,416 investors and have 6,858 funds involved in the transactions. Most of them are related to software – such as transformative and cutting-edge manufacturing enhancements, AI applications, cloud computing, clean technology, and big data. Deals involving AI solutions stand at the helm (13,562 deals), followed by cloud computing (8,513 deals) and clean technology (3,082 deals).

As for the projects funded, data centres have experienced a remarkable surge in primary stage projects in recent years. In 2020, USD 7.7bn flowed towards them, only for the figure to jump to USD 24.3bn in 2023, with a total of USD 45.6bn worth of data centre infrastructure projects not yet having reached financial closure. Fibre optic projects have also seen significant funding in the last several years, attracting USD 37.1bn and USD 22.5bn in 2022 and 2023 respectively, up from almost negligible amounts prior to 2020.

Looking at the geographical location of the InfraTech projects financed, investments are predominantly concentrated in developed economies, with North America and Europe at the forefront of primary deals. Nonetheless, the Asia-Pacific (APAC) region has shown significant growth in InfraTech investments, attracting USD 5.7bn worth of investments in the first half of 2024 – compared to USD 6.2bn for the whole of 2023.

Investment flows still stem predominantly from European and North American actors, with USD 41.2bn and USD 16.9bn in 2022, respectively. Nonetheless, investors from the APAC region emerged as significant players in 2023, contributing USD 7.2bn towards InfraTech projects.

Optimising conventional infrastructure at all stages of the lifecycle

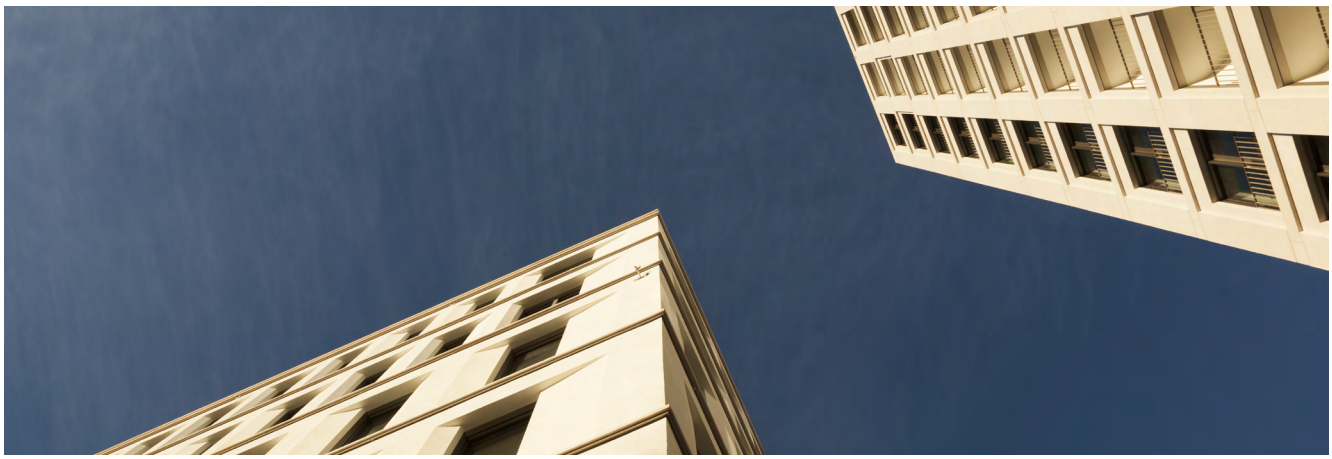
InfraTech solutions can and should be deployed at all stages of the infrastructure lifecycle:

Project planning, structuring and financing	Design, engineering and build stage	Operation and maintenance	Sustainability performance
The lack of digitalisation and data are among the key hurdles that derail infrastructure projects. Big data and machine learning can significantly help, with digitalisation being particularly critical both from a defensive perspective (ensuring that the asset does not become obsolete) and offensive perspective (capturing the best opportunities early on).	Implementing InfraTech solutions in the design, engineering, and build stages of infrastructure projects can significantly enhance efficiency, reduce costs, and improve overall project outcomes. For instance, drones and IoT-enabled sensors can provide real-time monitoring of construction progress and site surveying alongside quality control and safety management.	InfraTech solutions can track the entire lifecycle of an asset, from installation to decommissioning, and can help stakeholders make informed decisions on upgrades, retrofits or replacements based on comprehensive lifecycle data obtained. Digital twins, for instance, can significantly enhance monitoring and maintenance by using real-time data obtained from sensors to predict equipment failures and schedule maintenance at optimal times. Real-time data analysis paves the way for optimising operational parameters such as energy usage, production rates and resource allocation.	InfraTech solutions can play a key role in assuaging investors' concerns over ESG matters in infrastructure assets by reducing the need for error-prone manual processes and bringing more transparency and efficiency in the reporting process.

Changing business models

InfraTech solutions are bound to affect existing business models in the infrastructure sector:

Funding	Revenue models	Cost control and de-risking
Infrastructure investors are well positioned when it comes to InfraTech investments due to their long-term investment horizons, their deep sectoral expertise, and their ability to tap in relatively lower costs of capital. They can also leverage existing assets to test out InfraTech solutions. However, investing in InfraTech solutions may go beyond the traditional definition of infrastructure investment as low-risk, long-duration and predictable assets underpinned by contracted commitments and strong entry barriers. Infrastructure investors will need to ramp up their funding in early-stage InfraTech solutions, particularly at the first commercial operation stage.	Digitalisation can have a significant impact on revenue-generation in the infrastructure sector. As infrastructure projects increasingly become decentralised, digitalised, and service-based, the sector is increasingly shifting from infrastructure "projects" to "platforms," whereby assets are connected infrastructures which integrate mobility, technology and clean energy. From enhanced quality to improved efficiency and longer operational life, InfraTech solutions can deliver revenue-related value in various forms. This requires investors to no longer treat infrastructure as a 'fixed income' asset that generates stable cash flows with little need for active management, as this hands-off approach creates challenges when infrastructure sub-sectors face transformational changes.	Digitally-driven data-informed decisions and monitoring processes bring about cost savings as InfraTech solutions can improve the efficiency of infrastructure investments by reducing cost overruns. Be it enhanced data management and communication or upgraded analytical functionality and communication flows, the cost-related benefits such solutions bring are significant. As for risks, investors aiming to invest in InfraTech to market should recall that such solutions do not provide the kind of barriers to entry or captive market they may be used to in conventional infrastructure projects. Such investments rely on consumers who can choose between various providers, which hence brings forth a comparatively higher level of risk.



Risks and challenges to overcome

Although InfraTech holds significant promise throughout the infrastructure sector, it also brings forth risks and challenges.

Implementation risks	Lack of policy support	Technology risks
As InfraTech solutions are built on complex and novel technologies, a potential risk for unintended adverse impacts on safety and reliability exists. Such solutions also carry additional risks due to greater technological uncertainty, and existing structures and policies may not yet be ready to manage the complexity of procuring and rolling out InfraTech solutions.	When devising and implementing industrial policy, governments generally tend to focus on new "greenfield" projects and overlook the benefits that could be gained from upgrading existing assets with modern technologies. This leads to neglected opportunities to enhance the performance and longevity of existing infrastructure. In fact, the lack of clear InfraTech commitment from governments and the industry, coupled with the absence of leadership and policies explicitly advocating for the integration of digital technologies in infrastructure projects, are a significant hamper. As a result, individual initiatives lack coordination and the necessary support to succeed on a larger scale.	The proliferation of network connections in InfraTech systems has significantly expanded the risk of cyberattacks, which can have catastrophic impacts when implemented successfully on infrastructure systems. In addition, the risk of technological obsolescence complicates matters further, and given that InfraTech projects could become outdated or no longer fit-for-purpose, the risk of stranded and obsolete assets is very real.
Resource scarcity and environmental risks	**Societal risks**	**Geopolitical risks**
Resource usage and scarcity is already emerging as a bottleneck to digitalisation in the infrastructure sector. For instance, the water resources and electricity needed to cool data centres and power up AI applications pose a significant environmental challenge. Concerns are mounting over whether there will be enough energy derived from clean sources to meet AI needs, on top of the needs of other sectors, and certain jurisdictions have already stopped issuing permits to build new data centres. To preserve the value of their investments, infrastructure investors should be proactive in mitigating the adverse environmental consequences of their assets: data centres, for instance, can be designed to not only maximise energy efficiency but can also be retrofitted over time with state-of-the-art technology and upgraded during refresh cycles.	Within the broader scope of ESG risks, certain InfraTech solutions could pose significant societal risks. Uneven rollout may exacerbate the digital divide when it comes to accessing technologies and infrastructure services, while the exponential increase in data generated through InfraTech brings forth heightened cybersecurity risks and issues related to data privacy, protection, and confidentiality. The adoption of new technologies in the infrastructure sector could also result in labour/skill mismatches and disruptions in the job market and generate technology-driven unemployment.	The geopolitical dimension surrounding digital infrastructure cannot be ignored, given the current global political and economic landscape. As the world's largest powers compete against one another over technological leadership and strategic autonomy, infrastructure investors considering InfraTech solutions should always keep this backdrop in mind and be prepared to deal with any unforeseen repercussion.

Adopting InfraTech solutions is quickly becoming a strategic necessity for public and private players alike. However, achieving the promise and full potential of InfraTech requires substantial efforts and investments, and several key considerations need to be addressed.

Governments should enact adapted procurement tools and delivery models to enable further scale up of private investments needed to drive the digital transformation of the infrastructure sector. Accordingly, coordinated public-private collaboration – through public-private partnerships (PPPs) in particular – would incentivise the incorporation of InfraTech solutions into projects at all stages of the lifecycle.

By actively engaging in InfraTech PPPs, governments would not only leverage additional capital, but also offer private investors new investment opportunities. Establishing clearer, structured, regulatory frameworks would encourage the incorporation of technology into infrastructure, create a safer environment for private investors and foster increased investments in InfraTech.

Looking ahead, policymakers, industry leaders, investors, and all stakeholders should work together to harness the power of InfraTech and drive meaningful progress towards solving the socioeconomic and environmental challenges of our times. As a paradigm shift in infrastructure development and management, InfraTech provides a unique opportunity to build a more sustainable, resilient, and prosperous world. The opportunity is here – it is on us to seize it.

1

InfraTech: An introduction

The world is rapidly changing in increasingly unpredictable ways, with a growing number of complex and intertwined challenges heavily impacting societies, economies and the environment.

At the geopolitical level, international conflicts and territorial disputes are on the rise.[1] The Russian aggression on Ukraine, now well into its third year, is seemingly emerging as a protracted conflict, while tensions in the Middle East and the South China Sea are showing no signs of abatement. Developed economies, still reeling from the aftershocks of the COVID-19 crisis of 2020-2021, are increasingly struggling to remain competitive in the face of such political instability coupled with the rise of populism and increasing macroeconomic imbalances and socioeconomic inequalities.

When it comes to climate change and the environment, global warming is proceeding at an unabated pace, despite significant efforts by the public and private sectors to decarbonise economic activity. Rising sea levels, more frequent and intense extreme weather events, and other environmental consequences that threaten ecosystems, human health, and economic stability are increasingly becoming the norm. Such alarming developments are directly tied to environmental degradation, as air, soil, and water pollution alongside deforestation, biodiversity loss, and plastic waste accumulation in oceans are undermining the health of our planet, with many spillover effects on the economy and on food security.

Meanwhile, demographic changes are underway. The global population is expected to reach 9.7 billion by mid-century, bringing about further urbanisation, particularly in developing countries.[2] As such, existing pressure on infrastructure, resources, and the environment is only expected to continue and amplify in the coming years. Ensuring sustainable urban development – which includes affordable housing, clean energy, and efficient modes of transportation, to name a few – is of the utmost necessity as it is crucial for the well-being of growing urban populations.

This is where Infrastructure Technology, or 'InfraTech,' comes in.

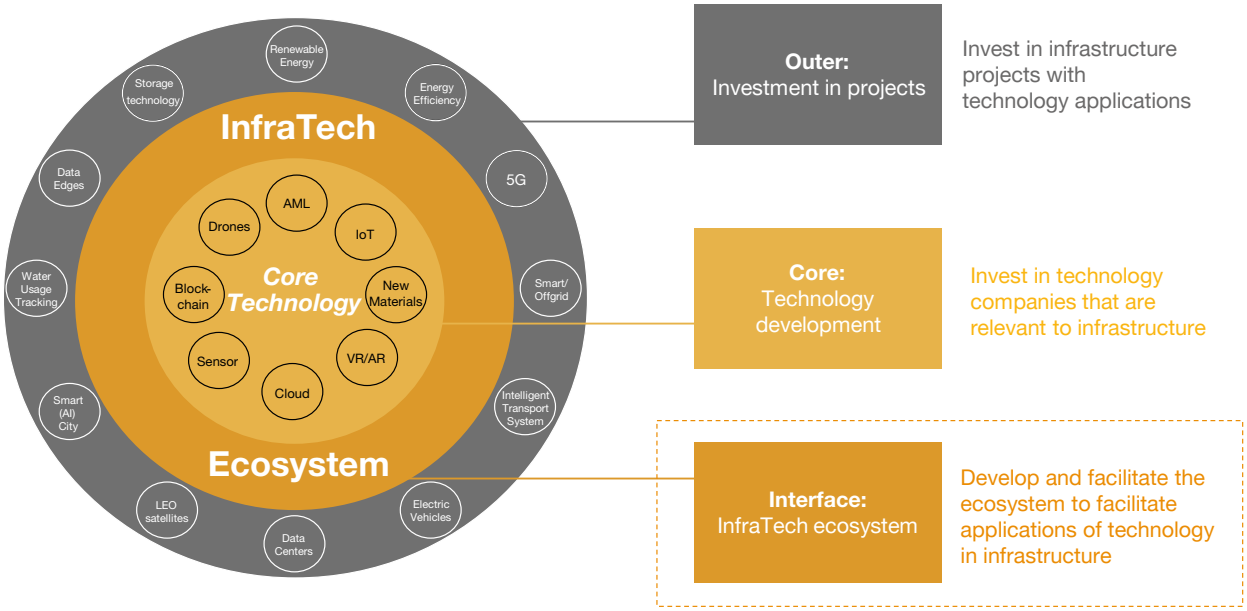
In the broadest sense, InfraTech refers to "any technology that significantly impacts the development, delivery, and ongoing operation of infrastructure." Such technologies help "meet the strategic requirements of infrastructure," "enable data-driven decision-making; innovations in finance, funding and fintech that support the commercial management of an asset;" and "are integral to managing the relationship a customer has with infrastructure and the consumption of its services."[3]

[1] PwC. 'From Compliance to Competitive Advantage: Risk and Performance in a Fractured World,' February 26, 2024. https://www.pwc.lu/en/regulatory-compliance/risk-performance-in-a-fractured-world.html

[2] United Nations. 'Global Issues: Population.' https://www.un.org/en/global-issues/population#:~:text=The%20world%20population%20is%20projected,surrounding%20these%20latest%20population%20projections

[3] World Bank. 'InfraTech Value Drivers,' July 2020. https://openknowledge.worldbank.org/server/api/core/bitstreams/da58a2fa-a901-5dfa-9058-71b38cd21e53/content

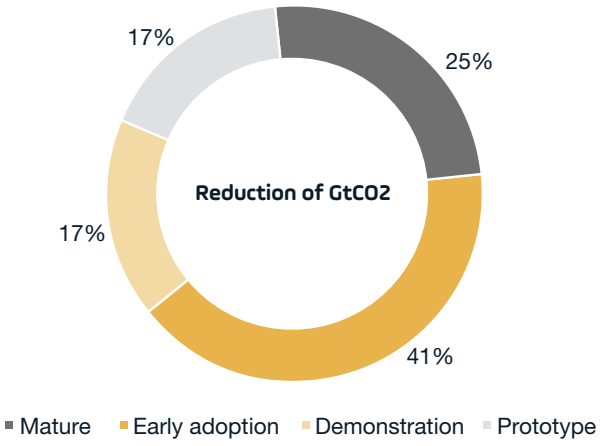
The InfraTech ecosystem can be categorised into three layers, as conceptualised by the Asian Infrastructure Investment Bank (AIIB) and the Global Infrastructure Hub:[4]



At the core stand investments in InfraTech development, which includes investments driven by start-ups, small and medium enterprises, and venture capital investors working on technological solutions – from IoT, unmanned aerial vehicles/ drones and virtual reality/augmented reality (VR/AR), to cloud computing and sensors, to name a few. On the other hand, the outer layer consists of investments in infrastructure projects, which involves the procurement and implementation of these InfraTech solutions.

By encompassing both digital and non-digital technologies, InfraTech offers a powerful toolkit to tackle head-on the many challenges our world faces and contribute to achieving international policy objectives such as the UN Sustainable Development Goals and the Paris Agreement. Indeed, according to the International Energy Agency, 35% of the cumulative CO2 emissions reductions projected for 2070 will stem from technologies that are currently at the prototype or demonstration stage (Exhibit 1).

Exhibit 1. Global energy sector CO2 emissions reductions by current technology readiness category in 2070



Sources: *PwC Global AWM & ESG Research Centre; IEA*

[4] GI Hub and AIIB. ´Stocktake of Approaches for Scaling Up InfraTech,' July 7, 2022. https://www.aiib.org/en/about-aiib/who-we-are/infrastructure-for-tomorrow/technology-enabled-infrastructure/_pdf/AIIB-GI-Hub-G20-stocktake-of-approaches-for-scaling-up-infratech.pdf

As a whole, InfraTech solutions contribute in several ways to improve outcomes which benefit stakeholders and society at large. The table below highlights three areas where InfraTech is particularly helpful.

Table 1. Key contributions of InfraTech

Enhancing climate resilience	Enabling more efficient use of resources	Attracting and mobilising private capital
By leveraging data and analytics to automate, monitor, and optimise operations, InfraTech builds resilience into infrastructure services. This ensures continued operations without disruption, even during extreme weather events, making infrastructure more resilient to climate change.	InfraTech enables cost-effective retrofits or upgrades to existing infrastructure. It extends asset life and optimises costly maintenance and renewals, allowing both industry and governments to achieve more with fewer resources.	InfraTech reduces overall project risk in conventional infrastructure by providing data and analytics for more informed decisions across the value chain and at all stages of a project lifecycle. With reduced or better-quantified risks and costs, infrastructure investment becomes more attractive to private capital and alleviates the burden on government budgets.

The InfraTech ecosystem involves extensive collaboration and communication between technology developers and infrastructure financiers.

However, when it comes to adopting technology and advanced digital tools, infrastructure has often been a laggard. Technology-enabled solutions are still mostly not proactively integrated into infrastructure planning considerations, and InfraTech is not yet viewed as critical to a project's success or to attracting private sector investments. For instance, when it comes to project finance, the process of developing and financing projects has barely changed over the last decades. Countless concessions or public-private partnership (PPP) agreements are still negotiated in person and drafted by hand, resulting in long delays and losses in productivity.

Nevertheless, the dramatic technological progress of the last decade has forced a rethink, and InfraTech's potential at all stages of the project lifecycle has begun to be tapped for delivering sustainable and resilient infrastructure and mobilising more private sector finance. Therefore, failing to properly take InfraTech into account can result in missed opportunities to maximise impact and enhance economic efficiency of the project over its lifecycle.

Box 1. InfraTech policy framework, a brief historical overview

In 2018, during Argentina's presidency of the G20, the 'Roadmap to Infrastructure as an Asset Class' was formally endorsed by the leaders of the world's leading economies in order "to tackle investment shortfalls as a way of lifting growth, job creation, and productivity."[5]

Two years later, InfraTech came to prominence during Saudi Arabia's presidency of the G20, as it became a topic for the G20 Infrastructure Working Group. In July 2020, the finance ministers and central bank governors of the G20 formally endorsed the Riyadh InfraTech Agenda.[6] In a nutshell, the agenda seeks to promote the usage of technology in infrastructure in order to (1) improve investment decisions throughout the project lifecycle, (2) enhance the value for money of infrastructure projects, and (3) promote high-quality infrastructure investments to deliver better socioeconomic and environmental outcomes.[7]

Thus, although it has long existed in numerous shapes and forms, InfraTech as a policy and framework is a relatively recent concept which emphasises the crucial role of technology in addressing crises, bridging the infrastructure investment gap, enhancing resilience and stimulating economic growth.

This report seeks to highlight the state of the current InfraTech ecosystem through a thorough mapping of the InfraTech funding landscape, a review of the main sectoral trends, their applications to infrastructure projects, and their implications for institutional investors, in terms of business models and allocation strategies. Drawing on concrete experience and feedback from LTIIA members, this report aims to identify the main takeaways and, when appropriate, table proposals to policymakers and infrastructure players.

Ultimately, this report seeks to foster awareness and understanding among institutional and private sector investors on the issues, obstacles, and opportunities in the infrastructure asset class to help catalyse and increase private investments in InfraTech projects and assets. As such, this report aims to contribute, however modestly, to enhancing the value proposition of the infrastructure asset class through the promotion of InfraTech solutions, and hence indirectly contribute to global sustainability objectives.

[5] OECD. 'Roadmap to Infrastructure as an Asset Class.' https://www.oecd.org/g20/roadmap_to_infrastructure_as_an_asset_class_argentina_presidency_1_0.pdf

[6] GI Hub. 'G20 Riyadh InfraTech Agenda endorsed,' July 20, 2020. https://www.gihub.org/news/endorsed-g20-riyadh-infratech-agenda/

[7] G20 Infrastructure Working Group. 'G20 Riyadh InfraTech Agenda.' https://cdn.gihub.org/umbraco/media/3008/g20-riyadh-infratech-agenda.pdf

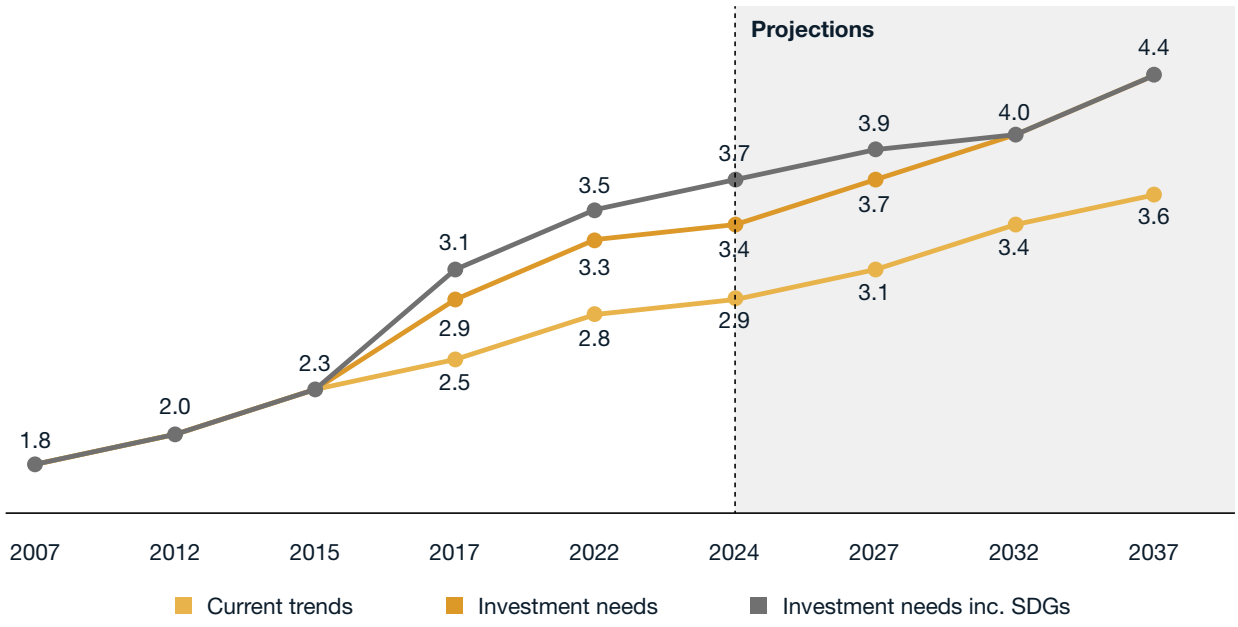
Current state of InfraTech

The infrastructure investment gap refers to the difference between current spending on infrastructure and the amount needed to meet future demand and goals. Many countries – both developed and developing – have aging infrastructure whose maintenance, upgrades or replacement have been deferred primarily due to constraints on governmental budgets. This existing infrastructure has generally struggled to keep pace with population growth and expectations.

In addition, while many governments have enacted regulatory frameworks to entice private sector participation in infrastructure development, the long-term nature of infrastructure projects coupled with the perceived risks have made many private, institutional partners hesitant to embark on such endeavours.

Thus, while investments into infrastructure have grown significantly since the mid-2000s – jumping from roughly USD 1.8tn in 2007 to USD 2.8tn in 2022 as Exhibit 2 below highlights – infrastructure development remains characterised by vast investment needs, a multi-trillion-dollar financing gap, together with a shortage of bankable projects.

Exhibit 2. Infrastructure investment volume at current trends and needs (USD tn)



Sources: *PwC Global AWM & ESG Research Centre, GIH, GIF*

InfraTech solutions can help bridge the financing gap. They vary in complexity and dimension, and include advanced technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI) and automation to continuously monitor and respond to real-time changes. Such intelligent and adaptable systems have the power to bolster the energy transition and underpin the foundation of the digital economy.

Faced with potential funding gaps and environmental goals, many governments and asset owners view technology as a means to optimise the value of their current assets and investments. Additionally, pressure from investors and asset owners is bringing forth a better understanding of how technology can improve the sustainability and resilience of infrastructure assets. They not only expect technology to be integrated into designs but also want assurances on how these assets will adapt to or incorporate new, possibly unforeseen, technologies in the future.

But to maximise InfraTech's potential, a multi-layered strategy is essential. The AIIB and the GI Hub have outlined 19 approaches to enhance InfraTech adoption through investment, categorised into four main pillars:[8]

Policy pillar	Commercial pillar	Technology pillar	Financing pillar
• National or sectoral InfraTech strategy. • Innovative procurement tools and policy.	• Public investment. • Innovative funds, platforms and de-risking mechanisms.	• Data platform or digital twin. • Cybersecurity and privacy measures.	• Innovative delivery models. • New platform for InfraTech ecosystem. • Granular finance-related data on infrastructure projects.

Implementing these pillars is crucial for effective InfraTech development as they can contribute to making governments' InfraTech plans more transparent to private investors, technology providers, and consultants, allowing them to invest more thanks to decreased capital requirements. This could propel InfraTech financing and increase its appeal to private investors.

While they do cover a wide scope of technologies and processes, InfraTech solutions essentially revolve around digital infrastructure. In the energy sector for instance, by enabling infrastructure systems to operate at peak efficiency through automated energy consumption control, demand response mechanisms, and the integration of renewable energy sources, these InfraTech solutions facilitate precise, efficient energy management. Real-time monitoring and control further enhance operational efficiency, allowing for rapid responses to emergencies and changing conditions, thereby bolstering the resilience of critical infrastructure systems.

As a whole, InfraTech solutions can be grouped into six non-exclusive categories, adapted from a World Bank reference note:[9]

Categories	Connectivity and communication	Analytics and computations	Cloud and data storage	Devices and automation	Platforms and interfaces	Materials, energy and construction
Description	Wired or wireless technologies that connect people or devices and enable data transfer.	Advanced analysis that uses machine learning (ML) to process large amounts of unstructured data.	Tech solutions that enable efficient mass movement and storage of large data sources.	Physical interfaces and components that perform specific tasks or enhance automation. This includes robotic sand drones.	Complex systems combining multiple technologies or that have whole of system design thinking.	Applying science and engineering to enhance efficiency and quality.
Examples of InfraTech technologies	5G and 6G mobile, LEO satellite, wireless broadband, IoT.	Big data, AI (incl. Autonomous Vehicles, ML and Deep Learning), auto cognitive and edge computing.	Cloud computing, HD video, building information modelling (BIM).[10]	Robotics (including UAVs/drones), batteries, wearables and biometrics.	Electric and hybrid vehicles, FinTech and InsureTech, blockchain, AR/VR, digital twin technology.	3D and 4D printing, nanotechnology, modular construction.

[8] GI Hub and AIIB. ´Stocktake of Approaches for Scaling Up InfraTech,' July 7, 2022. https://www.aiib.org/en/about-aiib/who-we-are/infrastructure-for-tomorrow/technology-enabled-infrastructure/_pdf/AIIB-GI-Hub-G20-stocktake-of-approaches-for-scaling-up-infratech.pdf

[9] World Bank. 'InfraTech Value Drivers,' July 2020. https://openknowledge.worldbank.org/server/api/core/bitstreams/da58a2fa-a901-5dfa-9058-71b38cd21e53/content

[10] "Building Information Modelling" is a process that visualises a digital representation of a physical asset through a 3D model.

By reshaping the governance framework and management approach, InfraTech solutions can have a significant positive impact on infrastructure and bring about a myriad of benefits to both businesses and citizens alike (see Box 2). Exhibit 3 below illustrates several InfraTech use cases.

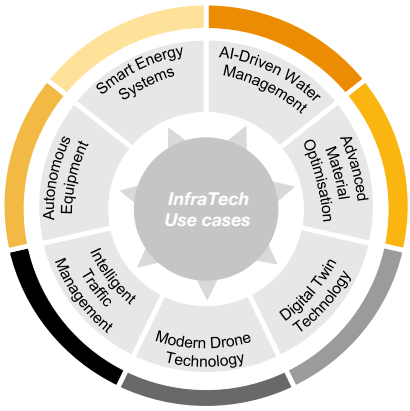
Exhibit 3. InfraTech use cases

Algorithms and Automation

The adoption of algorithms and automation is transforming the construction industry. Algorithms learn from past projects to improve execution, while automation enhances safety and efficiency by reducing human exposure to hazardous conditions.

Data Integration

The integration of data is essential for improving visibility and communication in infrastructure projects. Real-time data integration facilitates seamless communication among stakeholders, enhancing collaboration and decision-making. This data-driven approach streamlines workflows, increasing efficiency and productivity.



Agile Management Approach

The adoption of an agile management approach allows for interactive and adaptable design processes. Platforms are designed to be flexible and focused on developing use cases aligned with business objectives. Data-driven decision-making empowers designers with analytics for informed decision-making, optimising resource allocation and risk management.

Modern Geospatial Techniques

Modern drone technology offers faster, more accurate, and cost-effective data collection, revolutionising site surveys and environmental monitoring. Additionally, digital twin technology creates virtual 3D replicas of physical infrastructure, allowing for real-time monitoring, better decision-making, and risk mitigation.

Sources: *PwC Global AWM & ESG Research Centre; Geospatial World; T20 Italy; DigitalDefynd*

Box 2. Case Study: European Investment Bank's advisory services in support of the Romanian Governmental Cloud

Cloud computing is one of the key areas for future investments in digitalisation. It entails the delivery of computing services (e.g., servers, databases, software, analytics) and it underpins the deployment and usage of advanced technologies such as data analytics, AI, IoT, and blockchain. From lower upfront capital expenditures and reduced IT infrastructure and maintenance costs, to enhanced collaboration through shared resources and real-time file sharing and editing, to name a few, the benefits of the cloud for any kind of organisation are numerous.

In addition, by replacing large IT assets owned by various users and reducing the need to purchase additional ones within and outside the infrastructure sector, cloud computing is among the technologies that will contribute to achieving the sustainability goals of the European Green Deal as it positively impacts the environment.

The largest digitalisation investment in Romania is considered to be the set-up and deployment of the Governmental Cloud that will function in 4 data centres and is expected to include at least 30 IT systems or applications to be migrated in the cloud environment by mid-2026. The Governmental Cloud has an initial investment of roughly EUR 600mn in grants from the EU's Recovery and Resilience Facility. To support the implementation of this investment, the European Investment Bank is providing advisory services to the Romanian Government via its Project Advisory Support (PAS) mandate. EIB PAS advisory aims to support better planning and execution of EU funds and create good ground for EIB investments in the countries of its operations. Furthermore, it acts in economic and social infrastructure sectors such as transport, health, environment, energy and digital.

The EIB supports Romanian authorities in the design and running of the public procurement procedures for the migration of IT systems or applications in the Governmental Cloud, and delivers ad hoc support for the execution of indicated migration.

2.1. Sectoral overview

In virtually all segments within the infrastructure sector, cutting-edge technologies and digitalisation are transforming future outlooks, labour organisation and international competition:

- **Aviation:** To meet air traffic performance targets while building resilience through flexibility and scalability to cope with crisis situations, digitalisation is key. In addition, new technologies can improve the way aircraft fly through airspace, reducing fuel emissions on a flight-by-flight basis, making digitalisation an essential ingredient for the aviation sector to meet its decarbonisation commitments and achieve carbon neutrality.

- **Construction:** Probably the least digitised sector in the world after agriculture, the integration of innovative technologies – such as advanced project management tools, BIM, IoT and AI, to name a few – in the construction sector are significantly transforming construction processes, bringing about precision improvements in designing, developing, and building structures while simultaneously addressing the climate crisis by ushering in climate-resilient buildings.

- **Energy:** The energy sector is undergoing a steady process of innovation, with smart grids becoming increasingly important. Such innovative grids coordinate the needs and capabilities of generators, grid operators, end-users, and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impact while maximising system reliability, resilience, flexibility, and stability.

- **Transportation:** In **road transportation**, advances in smart infrastructure could lead to road networks becoming smarter, greener, safer, more efficient, and more resilient. An array of readily implementable innovative solutions exists today and can lead to reductions in emissions, delay times, energy consumption and other key indicators, while improving safety levels overall. As for **railway transportation**, digitalisation entails a denser flow of information on traffic and tracking, easier passenger access to services and information, more efficient use of infrastructure capacity, and a higher degree of timing predictability. Lastly, for **maritime transportation**, port automation is at the core of digital and technological strategies for maritime freight transport and port organisation. Smart port strategies are being adopted around the world to make national ports more efficient and more competitive internationally.

2.2. The specific case of AI

Zooming in on one specific technology, AI's adaptability and wide-ranging benefits have the potential to drastically enhance construction processes. It has been increasingly offering versatile tools with applications across various facets of the infrastructure sector by being embedded in several types of technologies, such as dash cameras equipped with GPS fleet tracking functions. As such, AI is enabling the automatic detection of accidents and incidents as well as predicting equipment maintenance needs, which not only enhances safety and performance, but also contributes to cutting costs.

AI is also being used to tackle growing environmental challenges, including through the energy transition. In fact, infrastructure firms can use AI to analyse climate data, optimise energy consumption, predict weather patterns, and develop sustainable solutions through AI-powered systems. However, while these solutions have the potential to optimise resource utilisation, reduce emissions, and contribute to environmental conservation, they also imply new environmental challenges. Indeed, as we shall see in Section 7, the data centres on which AI depends have high and rapidly increasing rates of water and electricity consumption.[11]

[11] Saul, J. et al. 'AI is already wreaking havoc on global power systems,' Bloomberg Technology, June 21, 2024. https://www.bloomberg.com/graphics/2024-ai-data-centers-power-grids/

Box 3. AI applications in Infrastructure

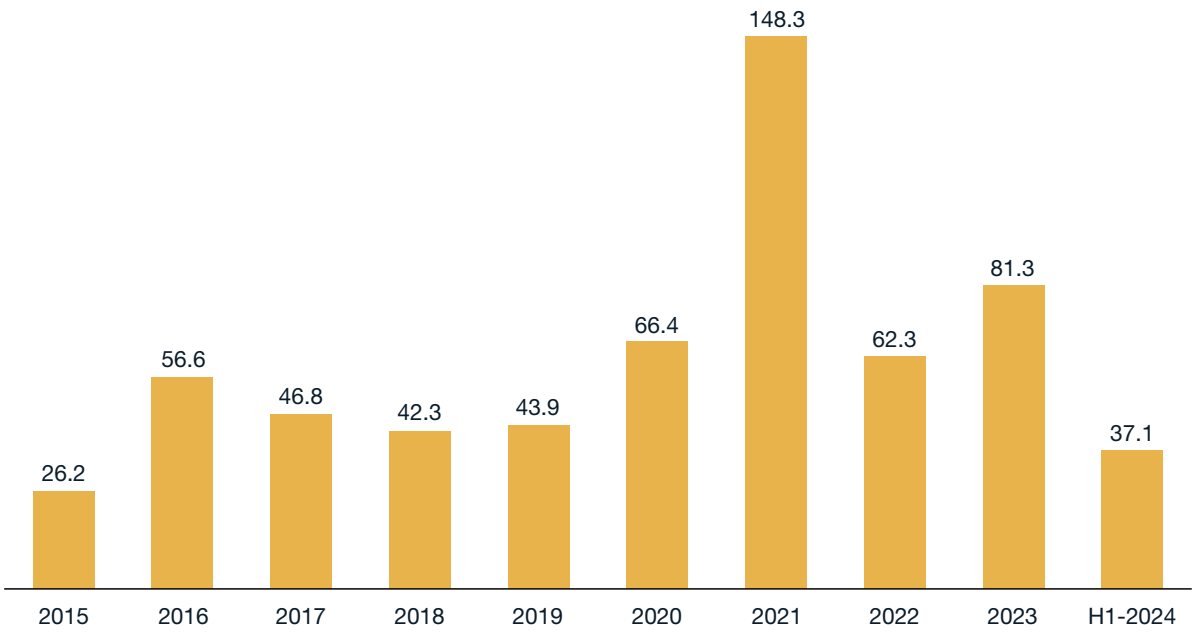
The fast-paced evolution of AI will likely result in several trends that will shape the infrastructure sector throughout the coming years.

For instance, infrastructure firms will increasingly turn to cloud-native applications due to growing application complexity, changing purchasing dynamics, and the demand for simpler design, provisioning, and operations. AI models will also increasingly become part of observability platforms, whereby the models can be evolved with continuous training and validation to enhance their accuracy and provide a better user experience over time.

In addition, generative AI (GenAI) is revolutionising software development, particularly when it comes to testing, security scanning, documentation, and code generation. It also enables the use of Natural Language Models (NLM) to trawl through the internet looking for, collating, and processing information on an unprecedented scale. Infrastructure firms will need to be cautious with regards to data sensitivity and intellectual property risks.

However, as previously mentioned, to date the digital transformation of the infrastructure sector has been relatively slow, and many infrastructure players are yet to embrace digitalisation to its fullest extent. Looking at AI, for instance, even though it holds the potential to level up and even upend the infrastructure sector (see Box 3), internalising AI tools requires significant investments in human capital, data centre capacity and funding, including in its clean energy provision dimension. Exhibit 4 below illustrates how investments backed by private equity (PE) and venture capital (VC) in AI InfraTech have fluctuated since 2015.

Exhibit 4. Global PE/VC-backed investments in AI InfraTech (2015 – H1 2024) (USD bn)



Sources: *PwC Global AWM & ESG Research Centre; Preqin*

Yet, it can reasonably be assumed that AI-enabled construction finance processes and monitoring could alleviate institutional investors' traditional reluctance and concerns to embark on greenfield investments and take on the associated risks. Such applications are already being developed and utilised in the market (see Box 4).

Box 4. Case Study: Taiyō.AI's data-driven platform to enhance infrastructure planning and productivity

Taiyō.AI's Global Infrastructure and Public Procurement intelligence platform aims to bring productivity growth to infrastructure planning by providing data and AI technology tailored to the industry's needs. By aggregating, cleaning, and delivering relevant infrastructure data, Taiyō.AI offers stakeholders the insights necessary for informed decision-making, especially during early project planning stages. The platform is the world's first AI-driven infrastructure intelligence platform which aggregates data from over 10,000 sources and provides them in a standardised and comprehensive format. This allows infrastructure players and stakeholders – from construction firms and government planners to infrastructure investors and asset managers – to easily search through real-time opportunities and learn from historical projects, while conducting and sharing risk analyses, and developing a better understanding of their competition and clients.

The benefits of Taiyō.AI's platform are wide and include:

- Identifying global opportunities through the largest dataset and the collection of infrastructure project and procurement opportunities.
- Diversified project coverage: Comprehensive access to over 20 categories and 60 subcategories, each with over 100 attributes per record. Data sites mesh 340,000 project records over 60 years, sortable by project stage and geography.
- Deep market insights: Insights can be gleaned from the activity correlations and connections over a 60-year period, including successes and failures by participant, geography, and project category.

Various beneficiaries stand to benefit:

1. For **engineering procurement and construction firms**, the platform can be used for business development as it offers them visibility into current and future opportunities and risks, and allows them to develop a better understanding of their clients and competitors through technical information/documentation, which ultimately improves margins and operational efficiency.
2. For **suppliers and subcontractors**, the platform allows them to search for RFQ opportunities, track the pipeline of existing megaprojects, and identify active buyers and recently-awarded projects, all of which results in better visibility into demand, reduction of inefficiencies, and supply chain optimisation.
3. For **governmental agencies**, the platform provides market insights, market sounding, and templates for procurement, and allows them to learn from prior experiences, evaluate providers, and access technical research for improved planning processes. It thus contributes to better project outcomes, fewer delays, and reduced cost overruns.
4. For **infrastructure investors and asset managers**, the platform enhances stakeholder identification and due diligence, which enables quicker go/no-go decisions.

Taiyō.AI's platform is gaining traction across the global infrastructure sector, as the following two cases illustrate:

- A large US construction company was facing significant challenges in manually parsing and aggregating project procurement reports from various sources. By using Taiyō.AI's platform, its search and data aggregation processes became streamlined, and the time required to implement such tasks was significantly reduced, from several hours to just one minute. Beyond the dramatic efficiency gains, Taiyō.AI's platform has also helped the company to quickly find and assess new projects and opportunities.
- Through Taiyō.AI's platform and AI-driven tools, a global construction company is now able to gather detailed insights and conduct thorough due diligence on potential projects, clients, suppliers, and stakeholders in a much more efficient and accurate manner. The platform also helps in generating quarterly and annual reports on market activity and stakeholder engagement, which provides management with valuable insights.

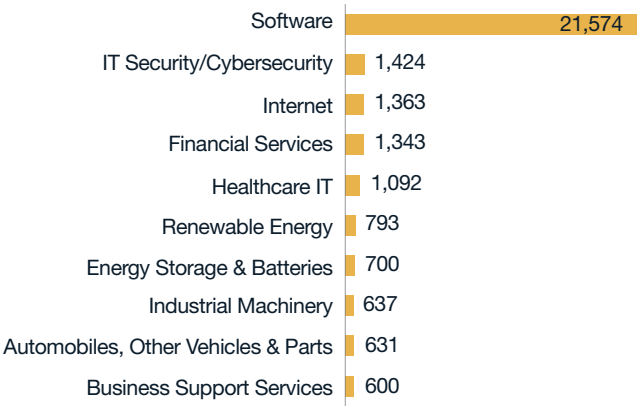
Private Equity and Venture Capital in the InfraTech Lifecycle

Our research is structured to capture the full spectrum of InfraTech deal activity, addressing diverse aspects such as data analytics, IoT, predictive maintenance, advanced construction, robotics, sustainability, energy integration, digital twins, smart cities and machine learning, to name a few. We included companies operating with both physical and digital infrastructure systems, recognising their multidisciplinary nature and critical role in modern infrastructure development and management.

Since 2015, out of 55,989 InfraTech deals made across the world, a little under two-thirds (63%) disclosed information. These deals are made up of 10,416 investors and have 6,858 funds involved in the transactions.[12]

As Exhibit 5.a. highlights, most of the deals are related to software – such as transformative and cutting-edge manufacturing enhancements, AI applications, cloud computing, clean technology, and big data. Indeed, with over 21,000 deals between 2015 and the first half of 2024, the 'software' category far overshadowed all other industry categories, with 'IT/Cybersecurity' coming in at a distant second with 1,424 deals.

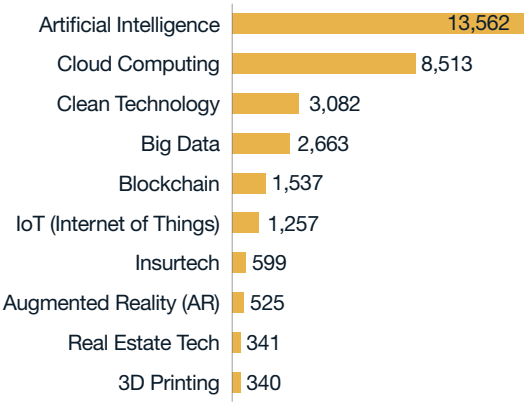
Exhibit 5.a. Top 10 categories by number of deals (2015 – H1 2024)



Sources: *PwC Global AWM & ESG Research Centre; Preqin*

When we zoom in on specific InfraTech solutions, with 13,562 deals, AI solutions stand at the helm, followed by Cloud Computing, standing at 8,513 deals. Clean technology – which entails companies engaged in activities such as energy efficiency, sustainable use of resources, or environmental protection – stood at a relatively distant third, with 3,082 deals, followed by big data and blockchain, with 2,663 and 1,537 deals respectively (cf. Exhibit 5.b).

Exhibit 5.b. Top 10 InfraTech solutions by number of deals (2015 – H1 2024)

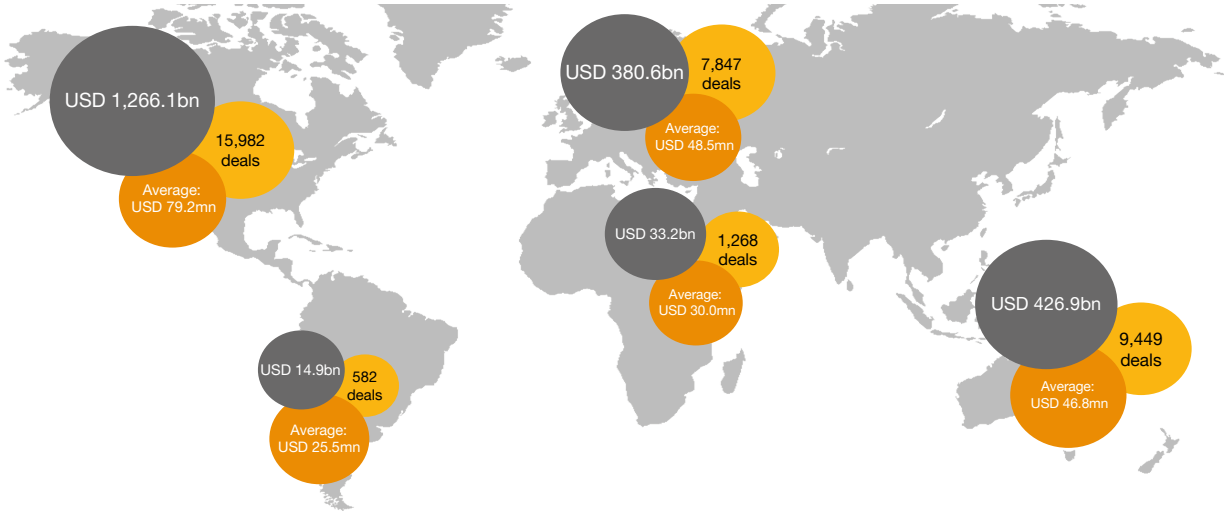


Sources: *PwC Global AWM & ESG Research Centre; Preqin*

As for the geographic distribution of disclosed PE and VC InfraTech deals, North America leads the way. In fact, between 2015 and H1 2024, the aggregate deal activity in North America amounted to USD 1,266.1bn – well above the USD 380.6bn and USD 426.9bn recorded respectively in Europe and the Asia-Pacific (APAC) region.

[12] Data from Preqin.

Aggregate deal activity by company domicile (2015 – H1 2024)

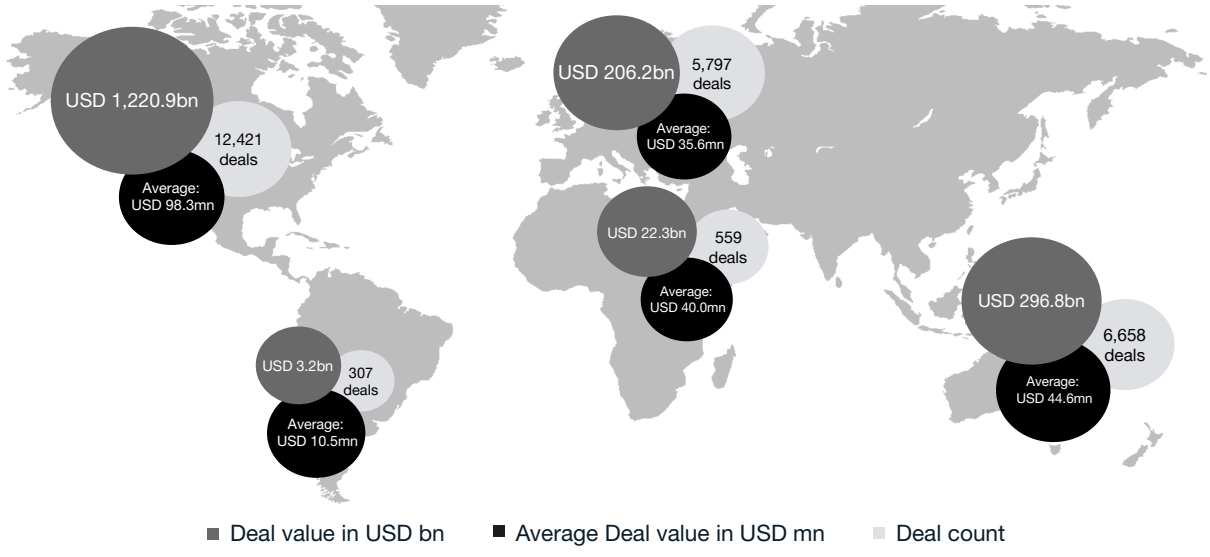


The United States' wide array of leading research and technology hubs alongside their proximity to sources of financing fosters an environment where cutting-edge InfraTech solutions can flourish. As a result, not only does North America have a higher total deal value than other regions, but its average deal size stood at USD 79.2mn – higher than the USD 48.5mn and USD 46.8mn average deal values in Europe and APAC respectively. The valuations of target companies reflect different stages of maturity of the market, the innovation premium associated with cutting-edge technologies, and the strong demand from a robust investment ecosystem.

On the other hand, the Middle East and Africa (MEA) region appears to be lagging. Total disclosed InfraTech PE and VC deals amounted to USD 33.2bn, with the average deal standing at roughly USD 30.0mn. As for the Latin America region, the region had the lowest number of deals alongside the lowest total disclosed deal value (USD 14.9bn).

Regarding the source of financing, American PE and VC firms are some of the largest and most influential players in the global investment landscape. Our analysis shows that they have committed around USD 1.2tn in InfraTech investments between 2015 and H1 2024 – more than the rest of the world combined. Investors from Europe and APAC stand well behind, with USD 206.2bn and USD 296.8bn in InfraTech investments respectively during the same period.

Aggregate deal activity by investor domicile (2015 – H1 2024)



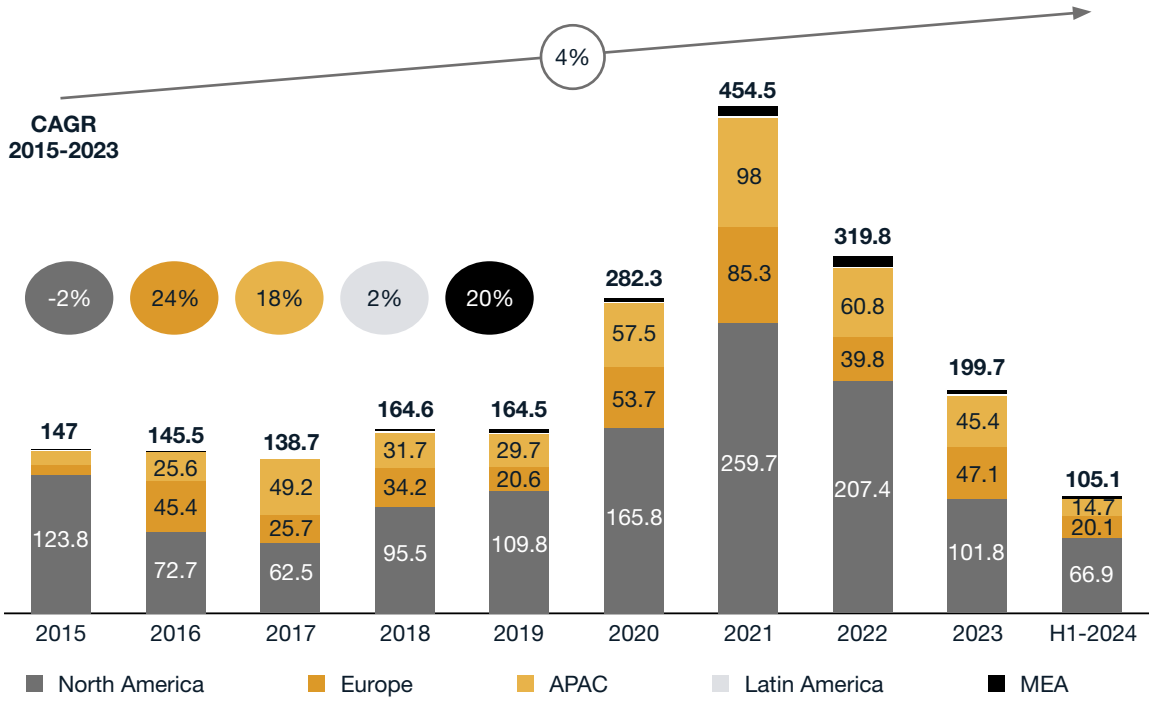
Note: Deal count might not add up due to undisclosed investors domicile.

Sources: *PwC Global AWM & ESG Market Research Centre; Preqin*

The average deal size for North American investors stood at USD 98.3mn, higher than the figures recorded for European (USD 35.6mn) and APAC investors (USD 44.6mn). This disparity not only reflects the greater availability of capital in North America, but also indicates that such investors are targeting more mature companies compared to their counterparts in other regions. As for the MEA region, the average deal size is significantly influenced by investors from Gulf Cooperation Council countries, who are increasingly focusing on local and international technology companies.

From 2015 to 2020, InfraTech deal activity steadily rose, reaching a first peak in 2021 with approximately 2,000 deals. However, in terms of aggregate deal value, the past two years have seen a decline in both the total deal size and the number of deals. This decline is largely attributed to a tighter macroeconomic environment, marked by higher interest rates that have slowed deal activity across all sectors, alongside a surge in geopolitical tensions. In 2023, total investment in InfraTech PE and VC reached USD 199.7bn (Exhibit 6).

Exhibit 6. Global InfraTech deal size by region (2015 – H1 2024) (USD bn)

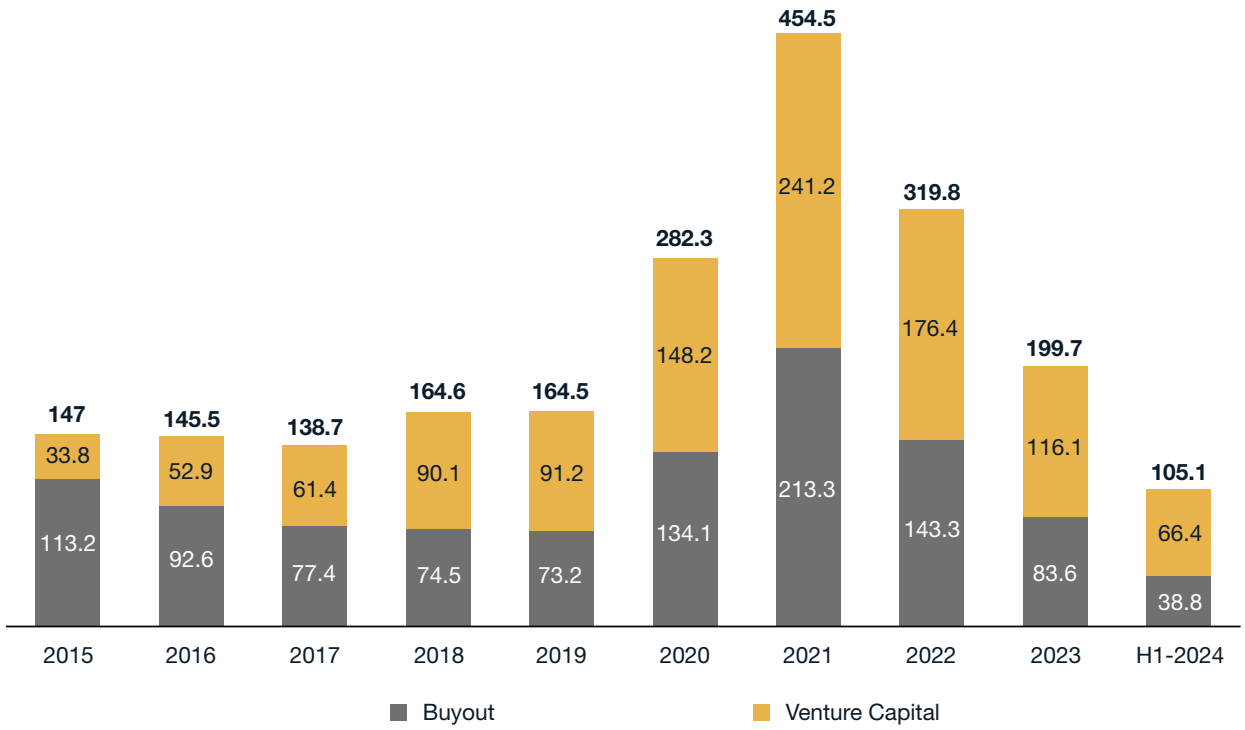


Sources: *PwC Global AWM & ESG Research Centre; Preqin*

While over half of the aggregate value of InfraTech deals in 2023 correspond to deals that took place in North America, the region's share has been declining since the peak of 2021. Indeed, Europe and APAC have benefitted from the post-COVID decline, whereby the two regions stood at 23.6% and 22.7% respectively of the total global PE and VC InfraTech transaction value in 2023. The MEA region still records a rather limited involvement in InfraTech transactions. However, deal size in the region grew at a compound annual growth rate (CAGR) of 20% between 2015 and 2023, indicating positive InfraTech growth prospects for the region.

Given InfraTech's focus on cutting-edge technologies, most of the activity in the sector now involves VC, with their share over the total of InfraTech deals soaring from 23% to 63% between 2015 and H1 2024 (Exhibit 7). This shift underscores a strategic move away from financing established corporates towards fostering the independent development of InfraTech solutions by younger, innovative companies.

Exhibit 7. Deal Value PE/VC (2015 – H1 2024) (USD bn)

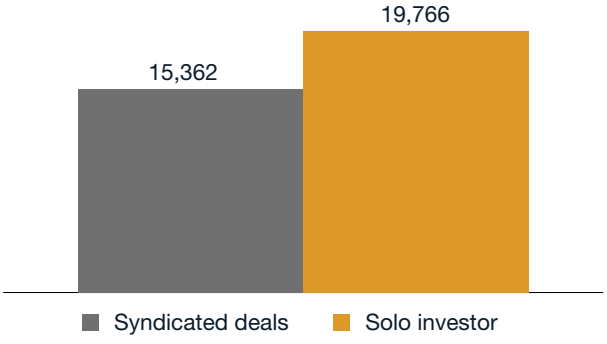


Note: All figures refer to disclosed deals.

Sources: *PwC Global AWM & ESG Research Centre; Preqin*

Most VC deals are solo deals, where a single VC firm invests independently, and for most of them, the type of deal remains unspecified. However, among the deals that are disclosed, Seed and Series A are the prevailing deal types with 8,499 and 6,519 transactions respectively, followed by Series B, Angel and Series C deals. In contrast, PE investors often engage in syndicated deals, where multiple PE firms collaborate to finance a single investment (Exhibit 8).

Exhibit 8. Number of syndicated deals vs. solo investors PE/VC (2015 – H1 2024)



Note: All figures refer to disclosed deals.

Sources: *PwC Global AWM & ESG Research Centre; Preqin*

Among VC firms, Andreessen Horowitz has been involved in the transactions with the highest values, totalling USD 6.5bn between 2015 and H1 2024. It also participated in 11 transactions (10 of which were as a solo investor) – the highest number by far. Beijing Chusudu Technology Company and Lykos Global Management stand at a distant second and third place, with one deal each and a solo transaction value of USD 1.1bn. Other relevant VC players include Intel Capital, Microsoft, Carlyle Group and Tamarace Capital.

Table 1. Top 10 VC InfraTech investors by number of deals (as a solo investor)

#	Player	Country	Solo Transaction Value (USD bn)	Solo Number of Deals out of Total Number of Deals involved in
1	ANDREESSEN HOROWITZ		6.5	10/11
2	BEIJING CHUSUDU TECHNOLOGY COMPANY		1.1	1/1
3	LYKOS GLOBAL MANAGEMENT		1.1	1/1
4	INTEL CAPITAL		1	4/4
5	MICROSOFT		1	1/2
6	CARLYLE GROUP		1	1/1
7	TAMARACE CAPITAL		0.7	1/1
8	TONGXIANG CITY CONSTRUCTION INVESTMENT GROUP CO.LTD		0.7	1/1
9	BOSCOLO INTERVEST		0.7	1/1
10	GENERATE CAPITAL		0.6	1/1

Note: The data in the table has been extracted from Preqin, covering the whole period between 2015 and H1 2024. Includes only deals in which the player was the sole participant.

Sources: *PwC Global AWM & ESG Research Centre; Preqin*

Unlike their VC counterparts, PE investors often engage in syndicated deals, where multiple PE firms collaborate to fund a single investment. As Table 2 below highlights, Francisco Partners is the leading PE firm in terms of transaction value for the period 2015 – H1 2024, with USD 2.1bn invested. It is followed by General Atlantic and Goldman Sachs Asset Management which invested USD 1.7 bn and USD 1.6bn respectively. Other major players include Blackstone Group, Macquarie Group, and Generation Investment Management, all participating in deals over USD 500mn.

Table 2. Top 10 PE InfraTech investors by number of deals (as a solo investor)

#	Player	Country	Total Transaction Value (USD bn)	Solo Number of Deals out of Total Number of Deals involved in
1	FRANCISCO PARTNERS		2.1	1/1
2	GENERAL ATLANTIC		1.7	1/1
3	GOLDMAN SACHS ASSET MANAGEMENT		1.6	1/1
4	BLACKSTONE GROUP		1.1	1/1
5	MACQUARIE GROUP		0.8	1/2
6	GENERATION INVESTMENT MANAGEMENT		0.5	1/1
7	CDHT HI-TECH VENTURE		0.3	1/1
8	CCT FUND MANAGEMENT		0.3	1/1
9	BAKER HUGHES US PENSION PLAN		0.1	1/1
10	CUMMINS INC.		0.1	1/1

Note: The data in the table has been extracted from Preqin, covering the whole period between 2015 and H1 2024. Only includes deals on which the player was the sole participant.

Sources: *PwC Global AWM & ESG Research Centre; Preqin*

Recent years have seen a surge in companies contributing to the fundamental infrastructure of AI applications – the full-stack transformation required to run large language models (LLMs) for GenAI. However, these technologies and related digital infrastructure are usually developed and kept in-house thanks to the unique size and financial capacity of Big Tech firms. Nvidia is the most well-known example as it has the most complete infrastructure stack for AI, including software, chips, data processing units (DPUs), SmartNICs, and networking.

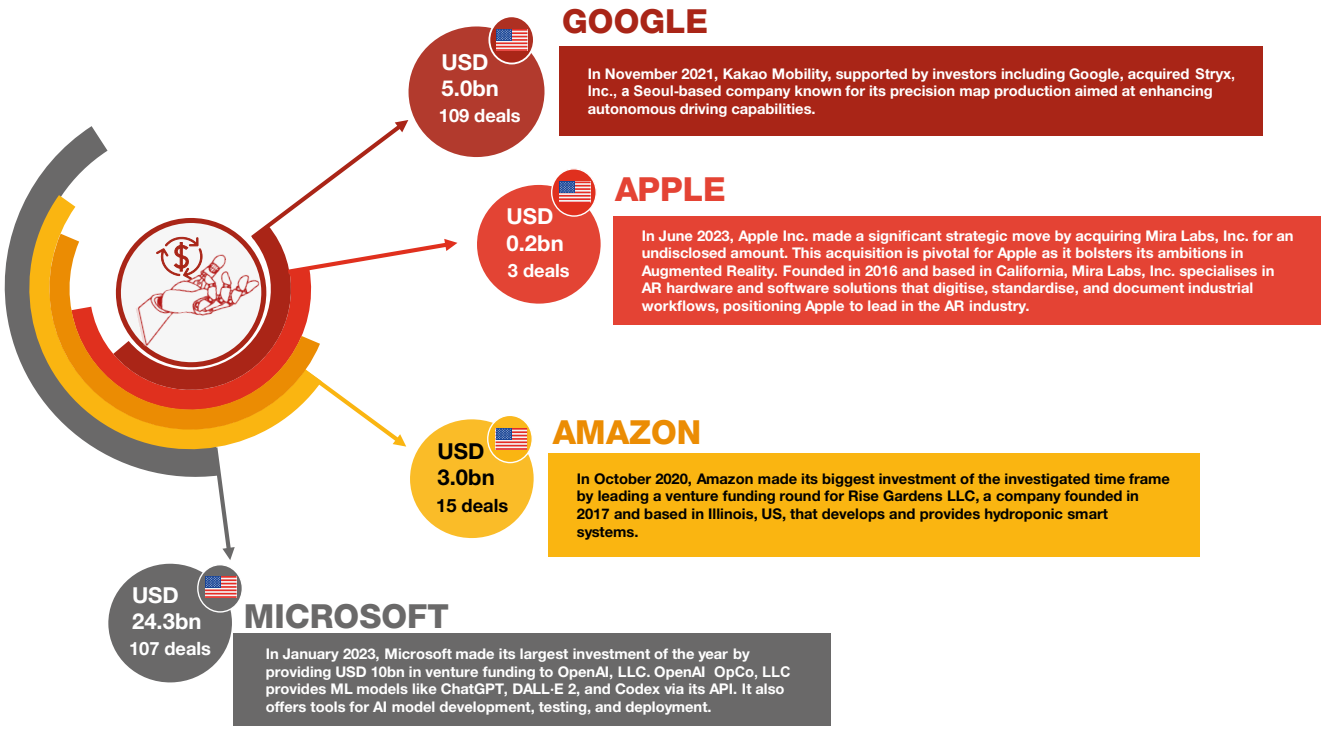
However, this does not mean that the Big Tech firms have shied away from technology-related PE/VC deals which could have InfraTech implications. For instance, Microsoft's USD 1bn investment in OpenAI in July 2019,[13] followed by its more recent investment in French startup Mistral AI,[14] illustrates the rising importance and forward-looking potential of GenAI in business applications. Mistral AI itself recently raised EUR 600mn from a wide array of corporate backers and investors such as Nvidia, Samsung Venture Investment Corporation, Cisco Systems Inc. and IBM.[15]

[13] OpenAI. 'Microsoft invests in and partners with OpenAI to support us building beneficial AGI.' July 22, 2019. https://openai.com/index/microsoft-invests-in-and-partners-with-openai/

[14] Dillet, R. 'Microsoft made a $16M investment in Mistral AI.' Tech Crunch. February 27, 2024. https://techcrunch.com/2024/02/27/microsoft-made-a-16-million-investment-in-mistral-ai/

[15] Bergen, M. 'Mistral Fundraises at €5.8 Billion Valuation to Rival OpenAI.' Bloomberg. June 11, 2024. https://www.bloomberg.com/news/articles/2024-06-11/mistral-ai-raises-600-million-from-nvidia-samsung-and-vcs

Exhibit 9. BigTech and InfraTech



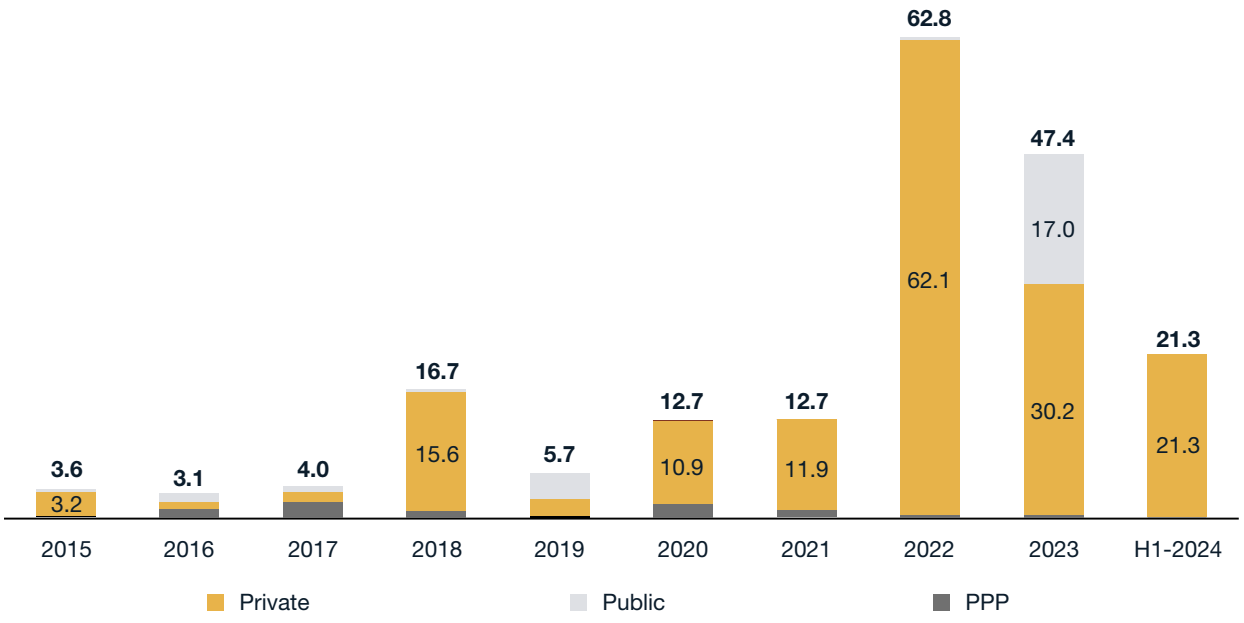
In all cases, precisely valuing InfraTech investments is challenging as they typically combine the acquisition of the technological know-how and the underlying digital infrastructure. Consequently, the next section will focus on primary investments into tangible digital infrastructure such as data centres and fibre optic.

Mapping InfraTech Deals and Investors

While InfraTech is still a relatively new asset segment, it has rapidly come to occupy an important position in investment portfolios, and its share of private infrastructure deals is estimated to have grown from 7% in 2018 to 17% in 2023, overtaking power and transport.[16] Given the growth of data centres and the anticipated demand for and rollout of AI solutions in various sectors in the coming years, InfraTech is expected to further grow. Out of 486 InfraTech infrastructure-related transactions between 2015 and H1 2024, 331 have reached financial closure while the rest are still at the pre-financing and financing stages.[17]

Historically, the private sector has consistently been the primary source of InfraTech funding, a trend that can largely be attributed to the predominant role played by asset managers. Indeed, as Exhibit 10 below shows, the majority of digital infrastructure investments were made by the private sector over the last nine years. However, an intriguing shift occurred in 2023, whereby USD 17.0bn in public spending was recorded.

Exhibit 10. Digital infrastructure investments; private, public and PPP (2015 – H1 2024) (USD bn)



Note: All figures refer to infrastructure projects that have reached financial closure.

Sources: *PwC Global AWM & ESG Research Centre; IJ Global*

[16] Real Asset Insight. 'Digital infrastructure now a staple in investors' portfolios.' April 20, 2024. https://realassetinsight.com/2024/04/20/digital-infrastructure-now-a-staple-in-investors-portfolios/

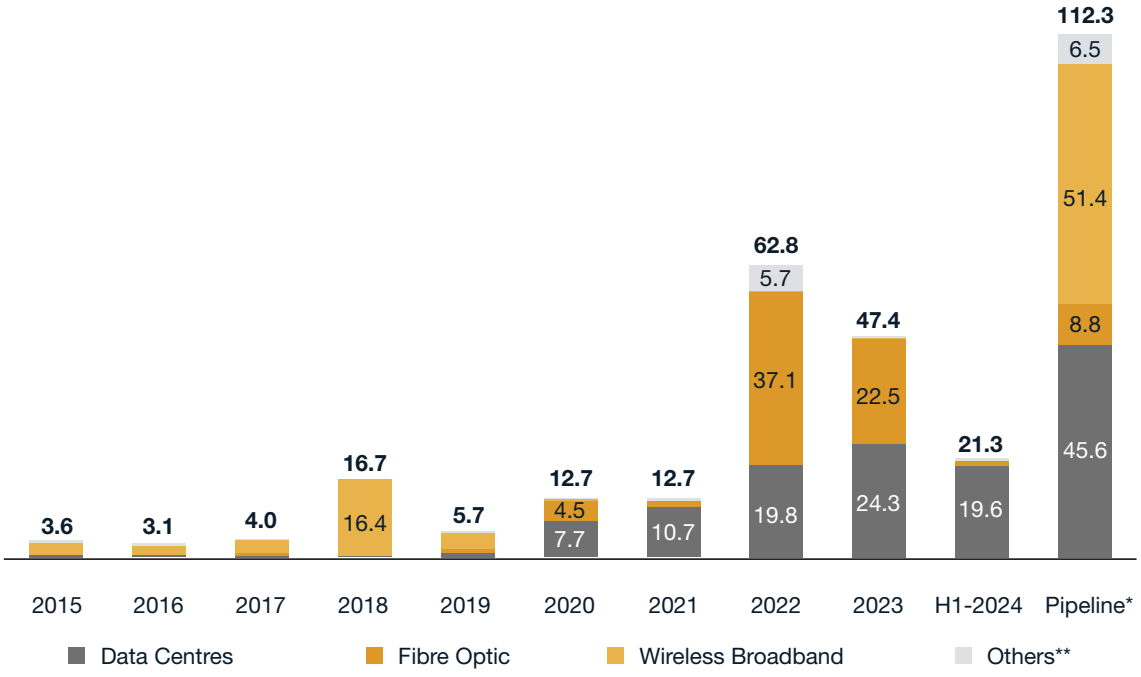
[17] Based on IJ Global data.

In November 2023, the US Federal Railroad Administration (FRA) made a groundbreaking move by awarding USD 16.4bn for 25 critical projects along the Northeast Corridor (NEC), which stretches from Boston, Massachusetts, to Washington, D.C. This substantial surge in public investment is aimed at enhancing infrastructure, improving transportation efficiency, and stimulating economic development throughout the region.[18] As a result of this investment, the public participation in InfraTech deals in 2023 was substantially higher than in preceding years, accounting for approximately 36% of the total deal value.

As for the projects being funded, data centres have experienced a remarkable surge in primary stage projects in the last few years. Indeed, in 2020, USD 7.7bn flowed towards data centres – only for the figure to jump to USD 24.3bn in 2023, with a total of USD 45.6bn worth of data centre infrastructure projects not having reached financial closure. Fibre optic projects have also seen significant funding in the last several years, attracting USD 37.1bn and USD 22.5bn in 2022 and 2023 respectively, up from almost negligible amounts prior to 2020 (Exhibit 10). This trend highlights the growing importance of expanding infrastructure technology, particularly in critical areas such as information systems.

Additionally, the rise in project deals for electric vehicle charging stations underscores the pivotal role of InfraTech in advancing the energy transition, especially as the debate over internal combustion engines intensifies in regions such as Europe and other leading economies.

Exhibit 11. Digital infrastructure investment by sector (USD bn)



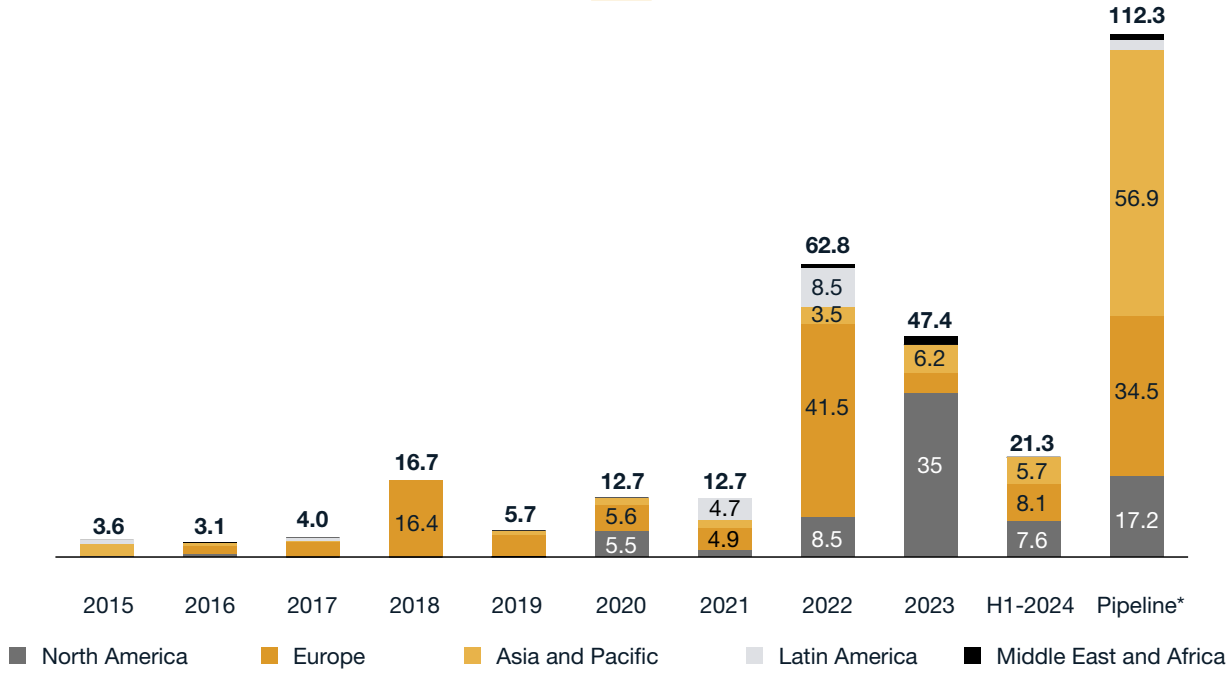
Note: *Refers to the aggregate of infrastructure projects that have not reached financial closure, presently in the pre-financing or financing stage; **Refers to: electric vehicle charging stations, high-speed rail, satellites, and submarine cables.

Sources: *PwC Global AWM & ESG Research Centre; IJ Global*

[18] Northeast Corridor Commission. 'Northeast Corridor Commission Announces CONNECT NEC 2037 : Plan initiates an era of reinvestment in Northeast Corridor rail network,' November 16, 2023. https://nec-commission.com/app/uploads/2023/11/C37-Press-Release1-Nov-23.pdf

However, when looking at the geographical location of the InfraTech projects financed, we notice that these investments are predominantly concentrated in developed economies, with North America and Europe at the forefront of primary deals. Nonetheless, the APAC region has shown significant growth in InfraTech investments, attracting USD 5.7bn worth of investments in the first half of 2024 – compared to USD 6.2bn for the whole of 2023 (Exhibit 12).

Exhibit 12. Digital infrastructure investment by asset's geographical location (USD bn)



Note: *Refers to the aggregate of infrastructure projects that have not reached financial closure, presently in the pre-financing or financing stage; **Refers to: electric vehicle charging stations, high-speed rail, satellites and submarine cables.

Sources: *PwC Global AWM & ESG Research Centre; IJ Global*

Primary deals involve new projects or enhancements to existing ones and can be further divided into 'greenfield' (developing entirely new infrastructure) and 'brownfield' (upgrading or repurposing existing infrastructure) projects.

Between 2015 and mid-2024, the number of digital infrastructure projects has grown significantly, with an increasing number of small-scale projects (with funding up to USD 150mn), particularly starting in 2021. As whole, during this period, 378 greenfield deals have reached financial closure, highlighting a substantial commitment to developing new infrastructure despite the higher risks involved. Brownfield projects are fewer in number and represent a smaller portion of the investment landscape with typically smaller deal sizes (Exhibit 13).

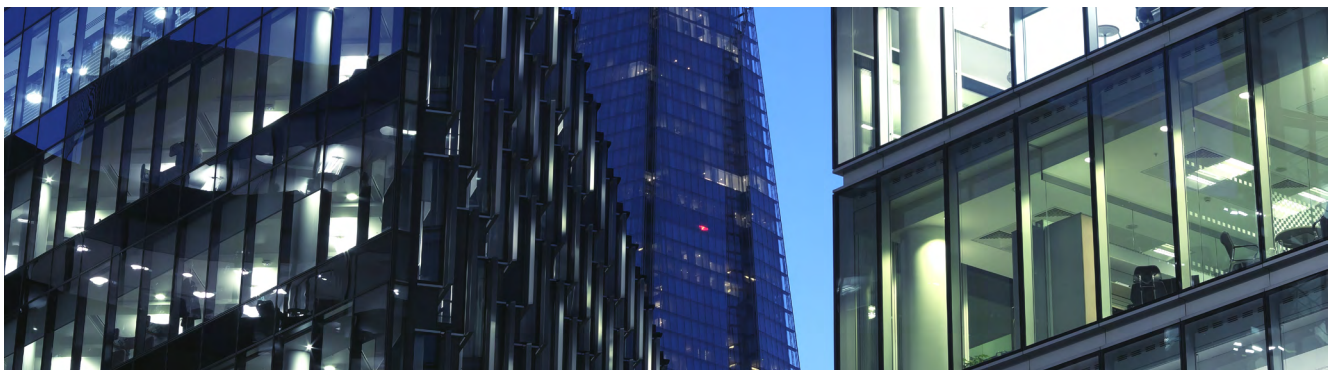
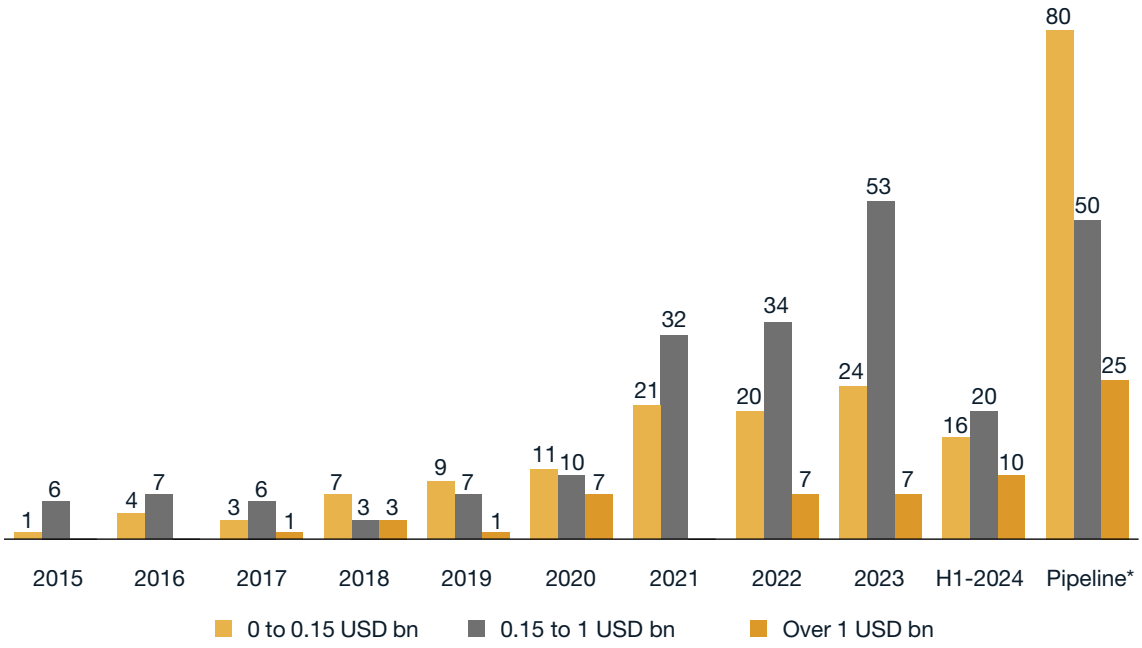


Exhibit 13. Digital infrastructure project counts by transaction value categories

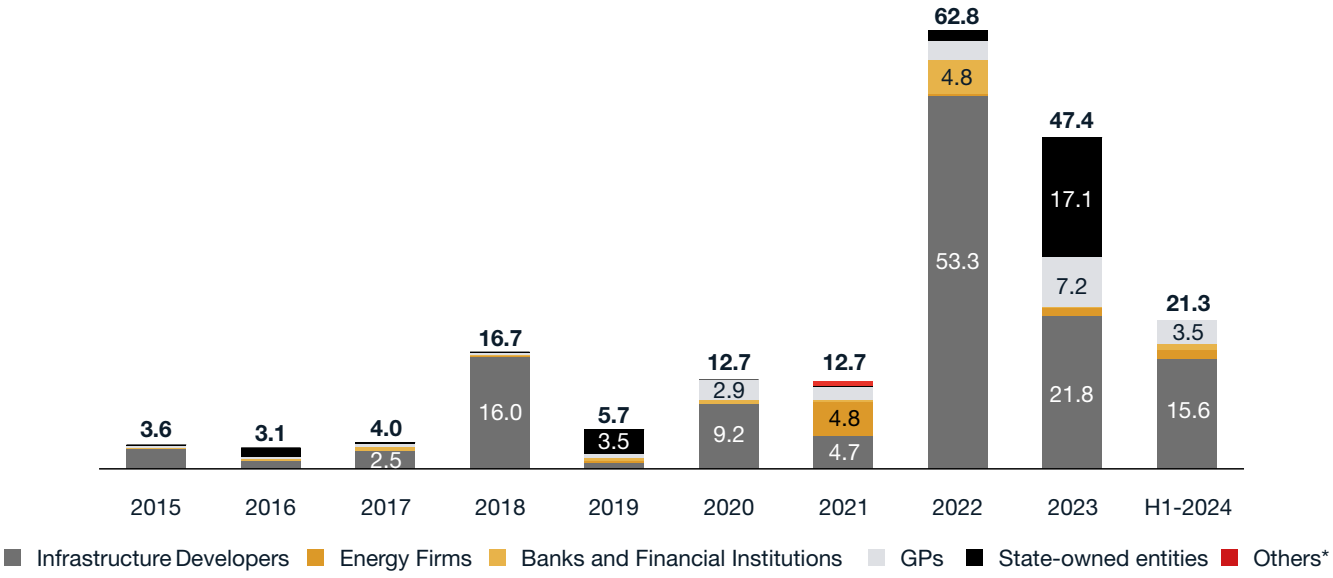


Note: *Refers to the aggregate of infrastructure projects that have not reached financial closure, presently in the pre-financing or financing stage.

Sources: *PwC Global AWM & ESG Research Centre; IJ Global*

Infrastructure developers are dominating the InfraTech landscape, with players in North America and the APAC region gaining ground in the last several years. This trend was particularly pronounced in 2022, when these developers poured approximately USD 53.3bn into digital infrastructure projects out of a total of USD 62.8bn. However, 2023 marked a shift in the investment dynamics of the InfraTech sector, whereby General Partners (GPs) significantly began ramping up their InfraTech investments (Exhibit 14).

Exhibit 14. Digital infrastructure investments by investor type (USD bn)

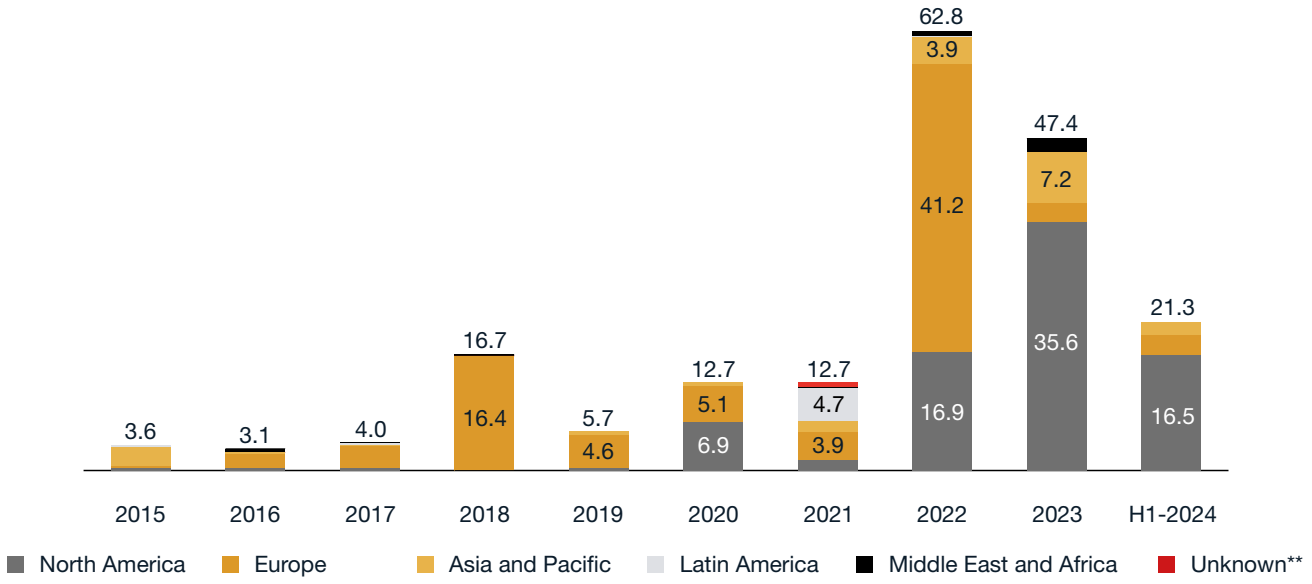


Note: *Refers to investors who are undisclosed.

Sources: *PwC Global AWM & ESG Research Centre; IJ Global*

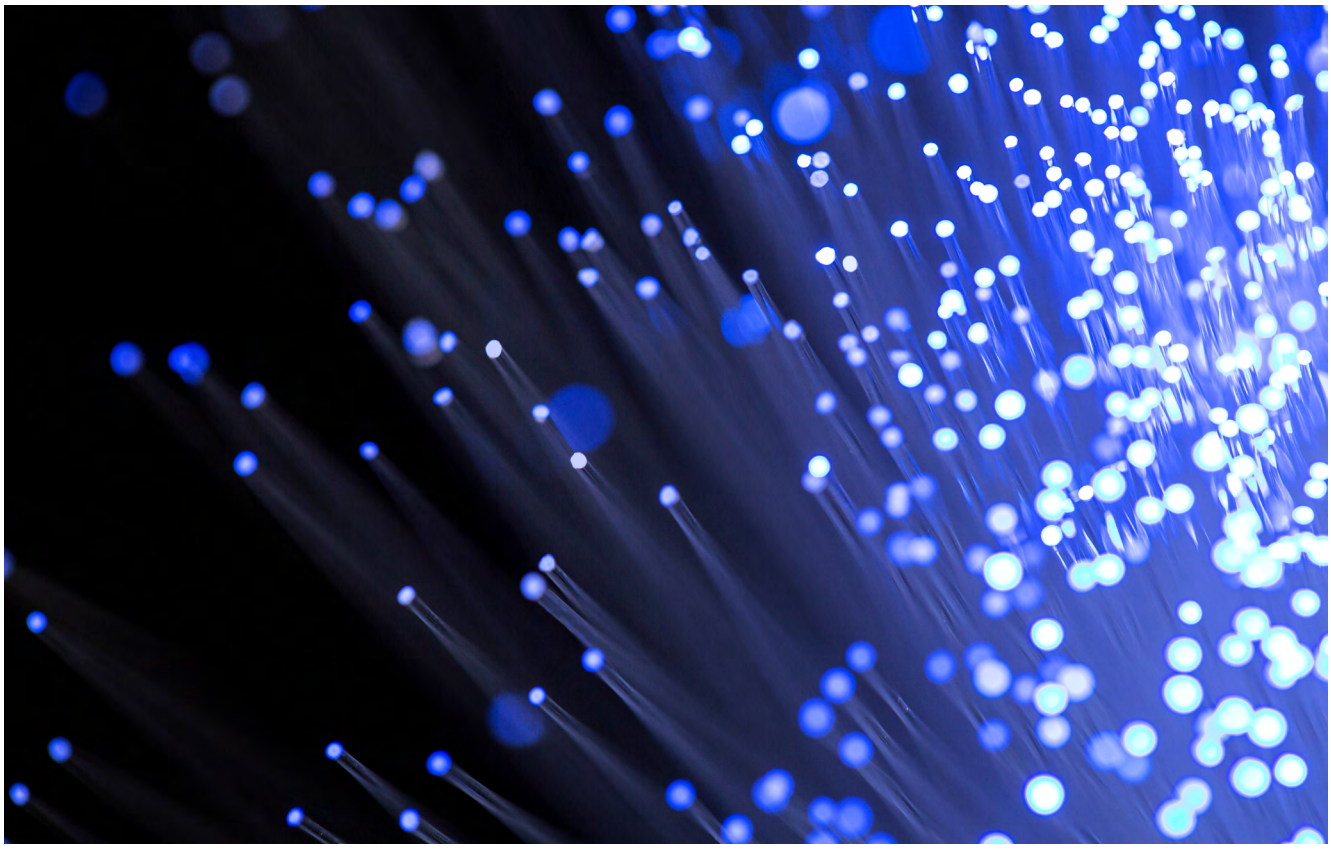
The investment flows remain predominantly from European and North American actors. Indeed, in 2022, European investors led the charge with USD 41.2bn, followed by their counterparts in North America with USD 16.9bn. Nonetheless, in 2023, investors from the APAC region emerged as significant players, contributing USD 7.2bn (Exhibit 15).

Exhibit 15. Digital infrastructure investments by investor region (USD bn)



Note: ***One of the deals and the related investor(s) have not been disclosed.

Sources: *PwC Global AWM & ESG Research Centre; IJ Global*



Optimising conventional infrastructure in all stages of the lifecycle

Adopting InfraTech solutions in the infrastructure sector is increasingly becoming crucial due to several overarching trends:

- **Bridging the investment gap:** As previously mentioned, addressing the energy, environmental and digital transitions in the infrastructure sector will require substantial investments. For instance, the decarbonisation of the building sector alone is estimated to require a budget close to USD 14tn.[19]

- **Increased Competitive Pressures:** Technology companies – particularly those at the cutting-edge of research and innovation – are making increasing forays into the infrastructure sector and partnering up with different players, whether to bring forth drastic efficiency gains or to embed sustainability within infrastructure projects. Meanwhile, some established infrastructure players are developing their own technology solutions to respond to the challenges they face. Thus, in the face of historically low industry margins and an increasingly competitive sector, adopting InfraTech solutions is becoming a key for survival.

- **Demographic transition:** The workforce in the infrastructure sector is aging, and given the broader demographic declines experienced in most advanced economies, finding and retaining staff across all levels of the corporate ladder will become further challenging in the coming years. In the United States, for instance, the median age of workers in the construction and extraction industries was 41.2 in 2022. As these workers retire in the coming years, infrastructure firms will struggle to fill in the positions needed.[20] Europe's infrastructure sector is facing similar challenges, with the European construction industry for instance continuing to suffer from a labour imbalance.[21]

These overarching trends – the investment gap, the increasing competitive nature of the sector, and the human capital needs – require an acceleration in InfraTech adoption. In fact, infrastructure, the largest and most capital-intensive sector globally, suffers from inefficiencies, high risks, and a lack of regulatory standards, particularly in data governance. Despite its critical importance and significant impact on sustainability, the industry has not seen productivity growth comparable to other sectors, and overspending remains a persistent struggle.

For instance, a 2020 study by researchers at the International Monetary Fund found that on average, countries waste about one-third of their infrastructure spending due to inefficiencies – a loss which can surpass 50% in low-income countries.[22] In addition, a more recent study by Bent Flyvbjerg, an economic geographer at the University of Oxford, found that out of more than 16,000 long-scale infrastructure projects from 20 different sectors in 136 countries dating back to 1910, "a staggering 91.5% of projects go over budget, over schedule, or both" –

[19] Santamouris, M. & Vasilakopoulou, K. 'Present and future energy consumption of buildings: Challenges and opportunities towards decarbonisation.' e-Prime – Advances in Electrical Engineering, Electronics and Energy. 2021. https://www.sciencedirect.com/science/article/pii/S2772671121000024#bib0097

[20] Phillips, Z. 'Construction's age problem: A foreboding exodus of experience.' Construction Dive. May 25, 2023. https://www.constructiondive.com/news/construction-labor-retirement-recruiting-dei/651184/

[21] European Labour Authority. 'EURES Report on labour shortages and surplus 2023.' 2024. https://www.ela.europa.eu/sites/default/files/2024-05/EURES-Shortages_Report-V8.pdf

[22] Schwartz, G. et al. 'How Strong Infrastructure Governance Can End Waste in Public Investment.' IMF Blog. September 3, 2020. https://www.imf.org/en/Blogs/Articles/2020/09/03/blog090320-how-strong-infrastructure-governance-can-end-waste-in-public-investment

and this applies to traditional infrastructure (such as bridges, airports etc.) as well as digital infrastructure.[23]

This is where considering InfraTech solutions in all stages of the infrastructure lifecycle can prove crucial.

5.1. Project planning, structuring and financing

Similar to other asset classes within private markets, unlisted infrastructure has traditionally suffered from limited transparency and a dearth of bankable projects, alongside risk management and liquidity issues.

Although investors are keen to invest in well-structured, sustainable infrastructure projects, project development and financing are proving to be significant challenges for infrastructure firms, and not enough investable projects are coming to market.

As a matter of fact, before a project can be financed, complex agreements (e.g., concession agreements, power purchase agreements, and loan agreements) must be in place. But the lack of a consolidated database of prior projects' terms or performance is a major hindrance, and without such data on what has been done before and what works, replicating success and scale becomes difficult. New infrastructure projects end up being structured and negotiated from scratch on a one-by-one basis, which is a time-consuming, risky, and costly approach.

Developing and financing a project can take years, and the "soft costs" of developing a project can typically be up to 10% (or more for small projects) of total project costs. For instance, assuming USD 500bn of debt and equity is invested in a year in the project finance market, project development costs would translate to around USD 50bn. If one takes a larger view and considers the approximately USD 2.8tn spent in 2022 by the public and private sectors in infrastructure investments (Exhibit 2), the amounts spent on project development become staggering, potentially amounting to USD 280bn per year.

The track record is not promising. Much of these sums is wasted, and many potentially viable projects end up never getting built. In fact, according to industry specialists, a staggering 90% of viable projects to which sponsors start committing capital end up never getting built, while roughly 45% of projects that do get built end up being renegotiated and restructured.[24]

Indeed, project development may devolve into a series of endless bickering and negotiations. Parties could find themselves negotiating for months on end about what governing law to use or what the liability caps should be for a construction contract. As negotiations drag on, legal expenses mount, and negotiating teams get frustrated. At some point, developers could run out of capital, governments may start losing patience, and the parties would walk away. What could have been a viable project that responds to the socioeconomic needs of citizens and businesses ends up never getting off the ground.

While some of the hurdles that tend to stop projects from getting off their feet are well-known – such as the lack of standardisation, the lack of government capacity, inadequate regulations, changing political will etc. – two critical digital-related ones stand out: (1) The lack of digitalisation and (2) the lack of data (Table 3).

Resorting to big data and machine learning can significantly help respond to these two major challenges and potentially usher in a new era for the infrastructure sector. Digitalisation in particular is critical both from a defensive and offensive perspectives – the former to avoid the asset becoming obsolete, and the latter to capture the best opportunities early on. Boxes 5 and 6 present two case studies of InfraTech solutions which have the potential to significantly resolve these two challenges.

[23] Akst, D. 'Why do large projects go over budget?' Strategy+business. June 19, 2023. https://www.strategy-business.com/article/Why-do-large-projects-go-over-budget

[24] Srinivasan, G. & Bergère, F. 'InfraClear: How digital technology can help generate more & better infrastructure deals.' LTIIA. May 1, 2021. https://www.ltiia.org/blog/infraclear-how-digital-technology-can-help-generate-more-better-infrastructure-deals/#_ftn2

Table 3. Lack of digitalisation and data – critical hurdles to better project planning

Lack of digitalisation	Lack of data
Little about project finance or the process of developing projects has changed over the last several decades. Project agreements are still drafted by hand while negotiations are done in-person. Microsoft's Excel spreadsheet, first released in 1985, is arguably the last technological tool adopted by project finance professionals.[25] The infrastructure sector needs to ramp up and speed up the way project finance is conducted, particularly given the new and increasingly-sophisticated digital tools now available, such as machine learning, natural language processing (NLP) and big data analytical techniques. More importantly, these tools do not necessarily require specialised training and can be used by lay users.	Data is the underlying foundation of the digital transformation across all sectors – and infrastructure is no exception. Decision-makers in the sector need data on how prior projects have been structured, their terms, risks, and performance. In addition, data on environmental, social and governance (ESG) and climate risks, regulatory risks, and other factors that could affect the project are also becoming indispensable. Data comes in many forms and from various sources. It can capture financial performance, ESG dimensions, as well as the legal and regulatory environment. Recently, the possibilities of data collected from technology-enabled sources (i.e., digital applications, satellite) are expanding and opening new perspectives. AI tools, such as NLP, also create new opportunities for optimising legal structuring and negotiating project agreements. Given that a lot of data on project terms, risks, and performance is already public, albeit heavily scattered, the opportunities for digital tools – and particularly NLP – to analyse data (such as legal contracts) and extract key information are very promising. The G20 recognised that robust and accessible data are needed for both private and public investors to make better-informed decisions about capital allocations to sustainable and quality infrastructure. This is encapsulated in the G20 Principles for Quality Infrastructure Investment[26] which emphasise access to adequate information and data as an enabling factor to support investment decision-making, project management, and evaluation. To this end, the G20 Infrastructure Working Group launched an Infrastructure Data Initiative (IDI) in 2017. It promoted discussion and coordination of initiatives among many public, semi-public, and private international institutions – among them the EDHEC Infra & Private Assets Research Institute, the Global Emerging Markets Risk database (joint initiative by the EIB and the World Bank), GRESB, Moody's, the Global Infrastructure Hub, the OECD, and other private sector representatives (including LTIIA). However, the initiative did not manage to come up with an operational roadmap.

[25] Srinivasan, G. & Bergère, F. 'InfraClear: How digital technology can help generate more & better infrastructure deals.' LTIIA. May 1, 2021. https://www.ltiia.org/blog/infraclear-how-digital-technology-can-help-generate-more-better-infrastructure-deals/#_ftn2

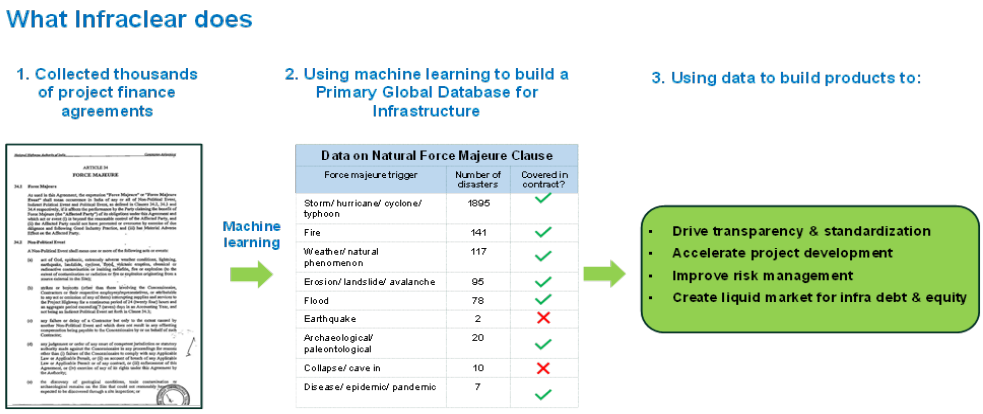
[26] https://www.adb.org/sites/default/files/linked-documents/reg-54036-001-tar-ld-02.pdf

Box 5. Case Study: Infraclear: How to use AI and big data effectively

Backed by venture capitalists, Infraclear is a US-based fintech/software-as-a-service company. With expertise in infrastructure finance, NLP, machine learning, and cloud computing, it seeks to "democratise infrastructure data" so that developing infrastructure projects becomes "radically easier."[27]

To do so, Infraclear has assembled one of the world's largest repositories of infrastructure project agreements and uses NLP and machine learning to extract data from these documents to build a primary database of project terms and risks. The kind of granularity provided by Infraclear's platform has never been available at scale before.

The diagram below presents in a simplified format what Infraclear does:



Based on the wide range of data available, Infraclear is currently building tools to address specific pain points faced by banks, developers, insurers, governments, and institutional investors.

Infraclear's platform seeks to meet the following objectives:

- **Simplify project development:** Data on the terms which have yielded better performance in the past can greatly help parties negotiating an infrastructure contract to avoid all the bickering that could derail a potentially viable project. In a scenario where an analyst can instantly pull up the liability caps for comparable recent projects and point out at what levels loan defaults were minimised, parties would no longer have to negotiate in a vacuum, and they could use the data to rapidly assess (a) what is the state of the market and (b) what works well.

  The availability of such data for all key terms of a project financing could have a dramatically positive impact on the initial phases of the project. Rather than spending months trying to find information, Infraclear's platform makes the data readily available at one's fingertips. It is estimated that ready availability of data could (i) reduce the time it takes to develop projects by 30%, (ii) reduce total project costs 3-6%, (iii) and increase lenders' margins by up to 10%.

- **Easily analyse risks in a portfolio:** A bank or an institutional investor could need several weeks to read through project agreements and understand the risks – climate and otherwise – that are not covered. The tools Infraclear is developing will allow them to analyse and rapidly understand the risks inherent in a project. With such information, a lender or a government could determine which project lacks protection against which type of natural event, and hence work with an insurer to protect their portfolio from climate risks.

- **Create a secondary market for infrastructure loans:** Nearly USD 3tn of infrastructure loans are outstanding, and less than 1% of infrastructure loans have been securitised despite several attempts by governments, multilaterals, and financial institutions to do so. Since infrastructure is an opaque and illiquid asset class, regulators force institutional investors to hold a lot of capital in reserve which makes securitisation costly. Granular data on project risks and performance will help bring transparency and comparability across projects and portfolios, and progress in this area may hold the key to a significant downward revision of capital charges requirements associated with securitising infrastructure loans, thus improving their return level.

[27] Council for Inclusive Capitalism. 'Infraclear.' https://www.inclusivecapitalism.com/organization/infraclear/

Box 6. Case Study: Finance to Accelerate the Sustainable Transition in Infrastructure, or FAST-Infra

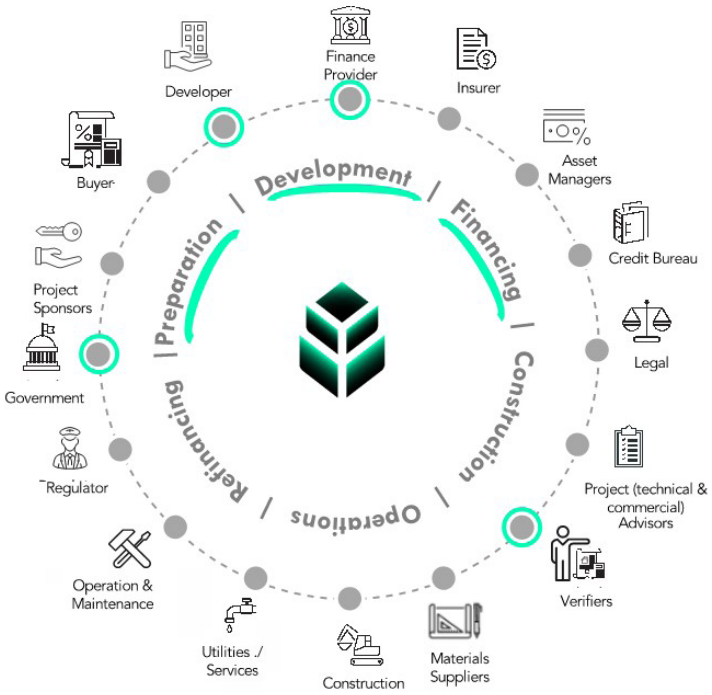
Infrastructure projects need to be sustainable, but should also make economic sense, which requires complex project risk analyses, management, and mitigation. This is currently only available for large projects only. This is where FAST-Infra steps in.

Co-sponsored by public and private entities to ramp up sustainable infrastructure financing, the industry-led and Paris-based FAST-Infra Group was established in 2022 and is backed by LTIIA and some of its historic members.

Beyond its label for sustainable infrastructure,[28] the group's FAST-Infra Platform (FIP) seeks to "support all stakeholders in the preparation, development, financing, and deployment of large-scale sustainable infrastructure programs," with a particular focus on emerging countries. The first version of the platform was launched at COP27 in November 2022.

FIP is an open-source, innovative, collaborative data-centric platform which redesigns collaboration between stakeholders in preparing, developing, financing, and deploying sustainable infrastructure around project data to facilitate and scale up project financing and refinancing of infrastructure projects of any size. Its core features are: (a) Common connection across the entire project lifecycle, (b) sustainable infrastructure project digital twin, (c) Industry level data aggregation and analysis, and (d) innovative industry applications.

The platform brings together a global user community of governments, developers, verifiers, and financiers across the sustainable infrastructure lifecycle by (i) "allowing them to cooperate, transact and manage their project data in trust across a sustainable infrastructure lifecycle," and (ii) "mobilising third-party technologies and innovation to leverage such data at project and aggregated levels."



The collaborative technology that underpins the platform eases data flows and enables transparent, standardised deals to mobilise private investment at scale. FIP seeks to become the "Market infrastructure for the Infrastructure market."[29]

Apart from the FIP, FAST-Infra Group is currently working on a plan to create a marketplace for infrastructure securitisation through an Open-Sourced Managed Co-Lending Portfolio Programme (OMCPP) whose syndication structure will allow a wide range of investors and multilateral development banks in emerging markets to participate in the market. The overall goal is to foster a deep and liquid market for the financing and refinancing of sustainable infrastructure projects and assets.

[28] https://www.fastinfralabel.org/

[29] FAST-Infra Group. 'FAST-Infra Platform: scaling and industrialising the infrastructure project lifecycle.' November 14, 2023. https://fastinfragroup.org/fast-infra-platform-scaling-and-industrialising-the-infrastructure-project-lifecycle/

5.2. Design, engineering and build stage

Implementing InfraTech solutions in the design, engineering, and build stages of infrastructure projects can significantly enhance efficiency, reduce costs, and improve overall project outcomes.

For instance, the aforementioned BIM technology can be used to create 3D modelling for better visualisation and to detect potential problems early on. GenAI-powered tools can optimise the design process, while AR and VR tools can enable immersive 3D visualisations of engineering designs, which subsequently allows engineers and architects to explore and interact with different models in a virtual environment. These tools also allow for immersive simulation of stress tests, fluid dynamics, and other physical phenomena on the models which helps to identify potential problems and challenges early on.

Moreover, advanced tools such as drones and IoT-enabled sensors can provide real-time monitoring of construction progress and site surveying alongside quality control and safety management (Box 7).

Box 7. Case Study: Upgrading construction sites with DJI's drones

Launched in China in 2006, DJI manufactures a wide array of drones that can be used in different settings – from agriculture, conservation, energy infrastructure, and search and rescue, to filmmaking and leisure, to name a few. In addition to China, the firm currently has offices in the United States, Europe, Japan, and South Korea.[30]

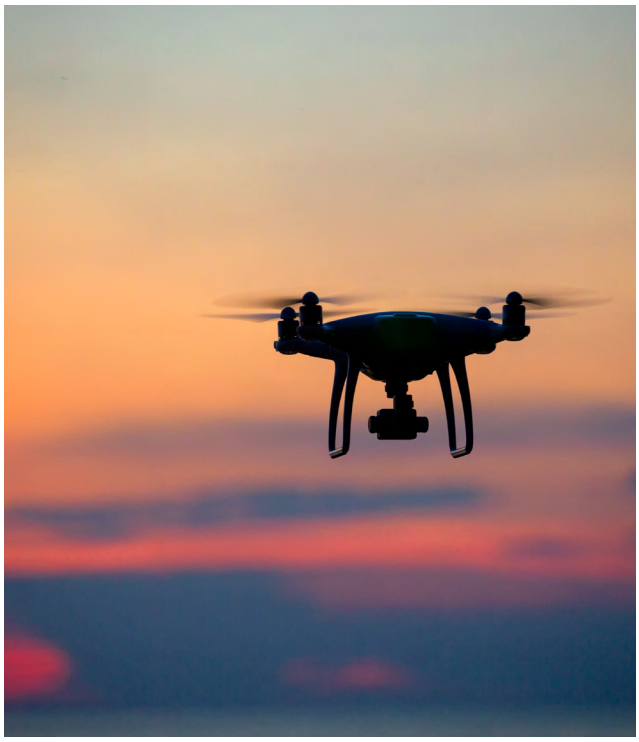
DJI's drones have many uses in the construction sector. For instance, construction crews can build accurate 3D maps based on aerial surveys conducted through their drones and can use them to carry out site inspections without putting workers in harm's way. The drones can also be used to build a digital twin of the building in progress which can help developers ensure that the designs comply with local codes and detect potential failure points. Aerial photographs taken by drones can also help construction crews keep track of material stockpiles and ensure that the equipment is secure.[31]

5.3. Operation and maintenance

By relying on comprehensive datasets, InfraTech solutions have the potential to transform operating and maintenance processes.

Digital twins, for instance, can bring about significant enhancements in real-time monitoring and maintenance by using real-time data obtained from sensors to predict equipment failures and schedule maintenance activities at optimal times ("predictive maintenance"). They also pave the way for real-time data analysis which allows for the optimisation of operational parameters such as energy usage, production rates, and resource allocation.

However, it doesn't stop there. InfraTech solutions can effectively be used to track the entire lifecycle of an asset, from the installation phase all the way to decommissioning, and can help stakeholders make informed decisions on matters such as upgrades, retrofits, or replacements based on comprehensive lifecycle data obtained from the different solutions.



[30] DJI. 'About DJI.' https://www.dji.com/company?site=enterprise&from=footer

[31] DJI. 'Drones in construction: Aerial assistance on the job site.' July 6, 2022. https://enterprise-insights.dji.com/blog/construction-drones

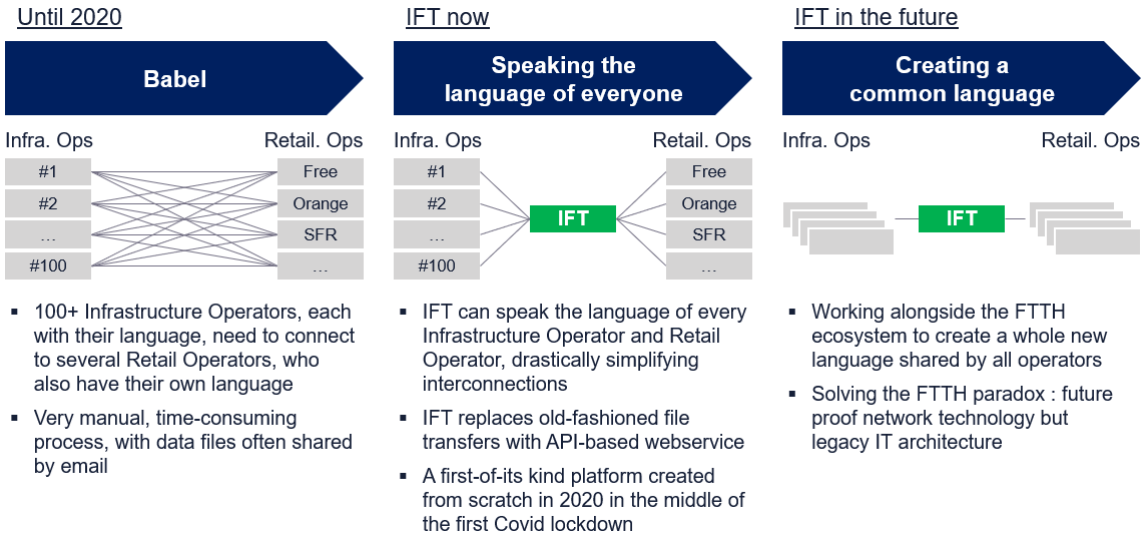
Box 8. Case Study: IFT, the first-of-its-kind IT platform connecting the entire FTTH ecosystem in France

Investissement dans la Fibre des Territoires (IFT) was launched in 2019 with the goal of financing fibre to the home (FTTH) across France so that more households and businesses can use high-speed fibre optic internet. The company is a joint-venture between Groupe Iliad – the parent company of French telecommunications operator Free – and InfraVia.

IFT was launched with the specific purpose of answering the following two questions: From an IT perspective, how can the right piece of fibre (infrastructure operator) be connected to the right retail customers (retail operators), particularly in rural and sparsely populated areas of France? And how can this process be made as efficient and safe as possible for around 30 million subscribers?

To that end, during the COVID-19 pandemic lockdowns, IFT developed a revolutionary IT interconnection platform enabling commercial operators to provide FTTH access in a secure, simple, and digital way from more than 100 infrastructure operators. In a nutshell, IFT acts as a middleman between infrastructure operators and retail operators by purchasing FTTH capacity from the former and retailing it to clients.

The diagram below explains how IFT functions:



- 100+ Infrastructure Operators, each with their language, need to connect to several Retail Operators, who also have their own language
- Very manual, time-consuming process, with data files often shared by email

- IFT can speak the language of every Infrastructure Operator and Retail Operator, drastically simplifying interconnections
- IFT replaces old-fashioned file transfers with API-based webservice
- A first-of-its kind platform created from scratch in 2020 in the middle of the first Covid lockdown

- Working alongside the FTTH ecosystem to create a whole new language shared by all operators
- Solving the FTTH paradox : future proof network technology but legacy IT architecture

The 'Babel' column on the left denotes the pre-IFT situation whereby linkages between infrastructure operators and retail operators were very complex due to a wide array of 'languages' (effectively a 'Tower of Babel' with approximately 100 infrastructure operators covering different areas, each with its own way of communicating its rollout). In the middle column, IFT has emerged to speak a language that all infrastructure operators understand and translates this to the language of retail operators.

Two French regulatory schemes have been key to accelerate deployment:

- Guaranteed no overbuild (except in the 3 largest cities), with open access to shared infrastructure to preserve competition on retail side.
- Co-investment scheme whereby retail operators can buy access through line rental or through co-investment in the deployment of the network (purchase of 40-year access through Individual Right of Use – IRU). Regulation makes it more economical than rental to boost rollout funding.

This private initiative then allows for economies of scale and a quicker deployment of the network, while ensuring all operators contribute to the capital expenditures, resulting in good coverage and high take up (up to 90%).

5.4. Sustainability performance

The impact infrastructure assets have on the environment and on broader sustainability factors cannot be ignored.

A recent report by UNOPS, UNEP, and the University of Oxford found that the infrastructure sector is responsible for roughly 79% of all greenhouse gas emissions.[32] In addition to linear transportation assets, even infrastructure assets that are key to decarbonising the global economy – such as solar parks – can have adverse effects on biodiversity, as they can "potentially take up large areas of land that serve as a habitat for plants and animals."[33] Meanwhile, child labour remains prevalent in numerous infrastructure-related activities in underdeveloped countries, while corruption in such countries can be endemic and require developers to pay hefty bribes which can derail the whole operation.

Facing these monumental challenges and problems, ESG infrastructure data collection and reporting is a very manual process which consumes a lot of time and resources. While regulatory authorities in certain jurisdictions have started clamping down on the practice, greenwashing remains prevalent in the market – a comprehensive global survey by PwC found that in late 2023, a whopping 94% of institutional investors believed corporate reporting contained at least some level of unsupported sustainability claims.[34] In addition, project-level assessments do not satisfy investors' reporting needs for a broader portfolio.

InfraTech solutions can play a key role in assuaging investors' concerns over ESG transparency and reporting in infrastructure assets (Box 9).

[32] UNOPS, UNEP and University of Oxford. 'Infrastructure for climate action.' 2021. https://content.unops.org/publications/Infrastructure-for-climate-action_EN.pdf

[33] Payton, G. 'Waking up to biodiversity loss.' Infrastructure Investor. November 6, 2023. https://www.infrastructureinvestor.com/waking-up-to-biodiversity-loss/

[34] PwC. 'PwC's Global Investor Survey 2023 – Trust, tech and transformation: Navigating investor priorities.' November 15, 2023. https://www.pwc.com/gx/en/issues/c-suite-insights/global-investor-survey.html

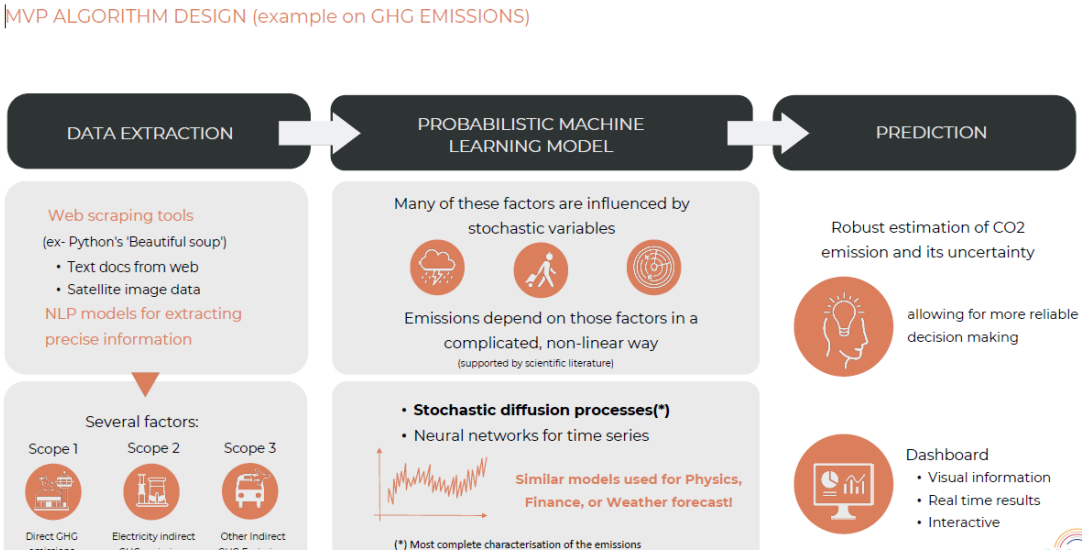
Box 9. Case Study: Infrawise, driving sustainability performance across infrastructure assets

Infrawise.ai

While still at the minimum viable product/proof of concept stage, Infrawise is a software-as-a-service (SaaS) solution that assesses and predicts sustainability performance of infrastructure assets through AI. By interlinking data with ESG frameworks, the platform seeks to:

(i) enable peer comparability and benchmarking through the leveraging of technology to generate data analytics, and
(ii) support regulatory compliance by simplifying sustainability reporting.

It can be used by both the public sector (national and sub-national agencies; infrastructure procurement agencies; PPP units etc.) and the private sector (debt and equity investors; asset operators; asset owners; asset managers; auditors, consultants etc.). For instance, Infrawise's solution can be used to assess Scope 3 GHG emissions of planned highways, using traffic prediction as a proxy, with predictive model given by a "Long Short-Term Memory" (LSTM) Neural Network (NN).



Box 10. The decarbonisation potential of cloud-powered technologies

New technologies now available in the market hold the key to huge potential strides in decarbonising infrastructure. In view of increasingly stringent climate-related regulations, cloud-powered technologies – such as AI, ML and the IoT – can play a key role in facilitating, and decreasing the cost of target setting, reporting, and compliance.

For instance, cloud technology makes compiling and consuming large data sets faster and cheaper, and AI-powered "decentralised data exchanges throughout the supply chain can enhance a company's understanding and transparency of its Scope 3 emissions data," paving the way for the company to uncover new and more cost-effective decarbonisation pathways.
In addition, by converting physical data from IoT sensors into digital information to create a digital twin, infrastructure companies can optimise or upgrade their decarbonisation efforts, be it when it comes to energy consumption and conservation, or to better manage the lifespan of the asset.

Lastly, ML models can leverage high-performance computing to find a balance between cost and carbon emissions – for instance, when it comes to logistics in the electric vehicles (EV) sector, complex ML simulations can be used to redesign products and optimise delivery and charging routes, such as determining where the optimal locations of EV charging stations would be.
Beyond decarbonisation measures, these three cloud-powered technologies can assist with reporting and compliance through the establishment of realistic sustainability targets "grounded in important internal and external data." As such, these technologies can be used to "avoid overshooting and greenwashing claims."[35]

[35] McKinsey & Company. 'Cloud-powered technologies for sustainability.' November 9, 2023. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/cloud-powered-technologies-for-sustainability

Changing business models

As InfraTech solutions increasingly gain traction and get rolled out throughout the world, existing business models in the infrastructure sector – ranging from the economics of funding to revenue-capture and cost-control dimensions – are bound to be affected.

This section will examine how these changes will be shaped.

6.1. Funding

As previously highlighted most investments in Infratech come from VC and PE investors. Apart from a few limited exceptions, most infrastructure investors lag behind in investing and developing InfraTech systems and solutions which can later be put to use to optimise their projects or the projects and assets of third parties. Indeed, a case can be made that investing in such InfraTech systems may go beyond the traditional definition of infrastructure investment as low-risk, long-duration, and predictable assets underpinned by contracted commitments and strong entry barriers.

However, a case can also be made that infrastructure investors may be uniquely well-positioned to take full advantage of these new InfraTech investment opportunities, particularly from the funding and structuring standpoints:

6.1.1. Fundraising players

Compared to other types of investors (corporates, VC, PE, etc.), infrastructure investors have several comparative advantages when it comes to InfraTech investments:

- **Long-term investment time horizons:** Compared to VC and PE investors, infrastructure investors tend to have long-term horizons when it comes to their investments, as they are fully cognisant of the usually long and lengthy development and implementation timelines that infrastructure projects usually take.
- **Deep sectoral and project-structuring expertise:** Infrastructure investors tend to have extensive knowledge of the sector they are investing in and the regulations underpinning it – whether it be in the transportation, renewable energy, logistics, telecommunications, or water sectors, to name a few. Unlike other corporate investors, they have developed both the ability to apply complex project-structuring skills as well as an expertise in setting up project-finance type vehicles (e.g., special purpose vehicles, non-recourse financing structures etc.) by knitting together a diverse array of business partners and contractors.
- **Ability to leverage existing portfolio of assets:** Infrastructure investors' control over existing infrastructure assets allows piloting InfraTech solutions in real-world environments and at scale, which is an option normally not afforded to other kinds of investors. This means that infrastructure investors have unique opportunities to test and refine InfraTech solutions, which accelerates their development and validation. In addition, by managing different infrastructure assets across various sectors and geographies, infrastructure investors tend to have an extensive network of industry contacts and partners, and can leverage these connections to drive InfraTech adoption and rapidly scale successful solutions throughout their portfolio.
- **Tap in relatively lower-costs of capital:** As they traditionally deal in lower-risk assets, infrastructure investors may be able to access lower-cost sources of funding, whether in equity or debt, to fund their InfraTech developments because of lower risk expectations – although this tends to be the case as long as the InfraTech dimension remains limited.

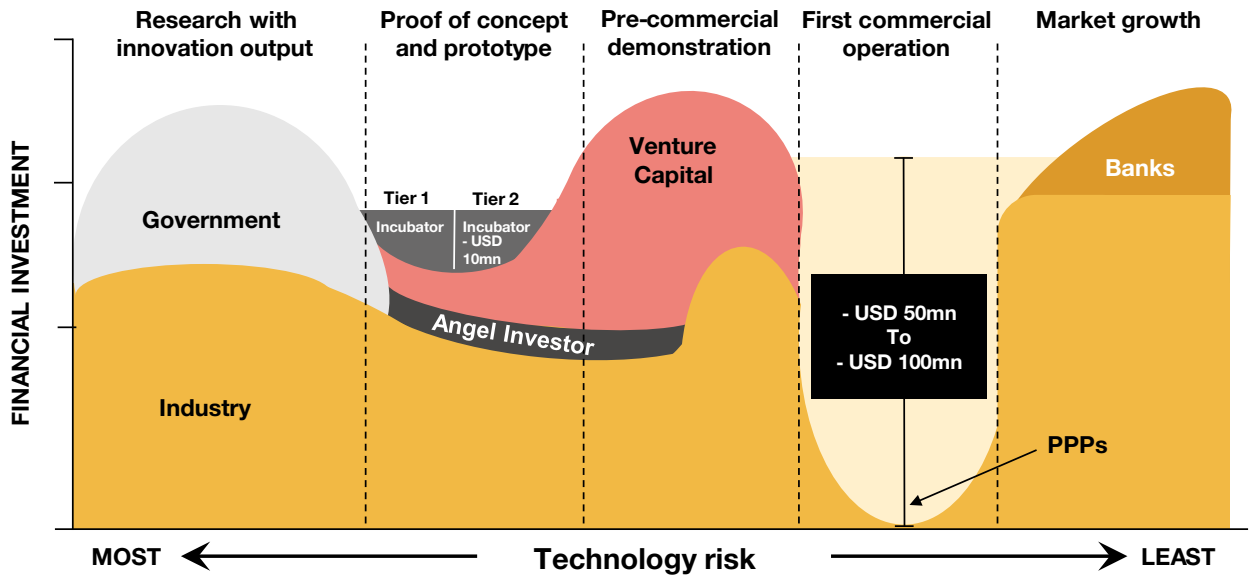
6.1.2. Funding models

Although sophisticated project structures in Europe are pursuing hybrid funding models, which generally lock in half of the project revenues into contracts and leave the rest under merchant risk to achieve optimal balance, the funding landscape for InfraTech solutions and projects is fragmented.

Providing funding for research is primarily done by governmental agencies and the industry, while investing in developing prototypes is mainly conducted by VC/PE investors. Infrastructure investors are needed to ramp up their act when it comes to early investment in InfraTech-enabled projects, particularly in the first commercial operation stage, as this is crucial to demonstrate the solution's potential and pave the way for market growth and subsequent financing from traditional sources such as banks.

The exhibit below, adapted from the Maryland Energy Innovation Accelerator, highlights the chronological sequence of InfraTech investment.

Exhibit 16. Hypothetical chronological sequence of InfraTech investments



Sources: *Maryland Energy Innovation Accelerator*[36]

[36] https://mdeia.org/f/announcing-the-maryland-energy-innovation-accelerator

Box 11. Case Study: InfraVia – combining investments in technology and infrastructure

Although Europe has a solid VC ecosystem alongside renowned research hubs and universities, an equity gap persists when it comes to late-stage funding to support successful start-ups before they reach the IPO and corporatisation stage. The challenge is to identify and accelerate the successful start-ups that operate in the infrastructure sector, not only through funding, but also thanks to industry knowledge, networks, and the quality of the infrastructure sector ecosystem at large.

This is where institutional investors can step in, and long-time infrastructure investor InfraVia Capital did just that.

In November 2019, InfraVia announced the launch of the Infravia Growth Fund, a fund dedicated to investing in and supporting "tech companies at scale-up stage."[37] As per Vincent Levita, InfraVia's founder and CEO, "digital is transforming infrastructure business models and usage" across all facets of the infrastructure sector, with startups emerging "to develop digital tools that will help operators to improve productivity, boost revenues, reduce risks but also increase capacity and quality of services to users." In fact, such InfraTech solutions "will lead to unprecedented opportunities in terms of growth and performance for infrastructures." InfraVia first began such InfraTech investments through its portfolio companies, but quickly came to realise that the scale "was so big" that a standalone strategy to address this was needed – and the InfraVia Growth Fund was born.[38]

Since then, the equity fund focused on business-to-business solutions has raised over half a billion euros[39] to invest in over a dozen growth-stage companies that provide technology solutions to the infrastructure sector.[40] Although such investments are generally high-risk, InfraVia has built a strong track-record throughout the years by investing in digital infrastructure – be it data centres, fibre networks, or smart meters.

6.2. Revenue model: capturing the value in infrastructure services

Digitalisation, and particularly AI, can affect revenue-generation in infrastructure services in many ways. For instance, better data collection and processing can bring about better market insights or enable more tailored "user-pay" schemes.

In any case, the following dimensions need to be factored in:

6.2.1. The benefits of "platforming"

To fully capture and leverage the benefits of technology, infrastructure needs to be seen not merely as a physical asset, but also as an asset that provides both a service and an outcome. Accelerating the adoption of InfraTech solutions thus requires changes in practice and more industry-level partnerships.

Indeed, the landscape is shifting from infrastructure "projects" to infrastructure "platforms," with projects becoming increasingly decentralised, digitalised, and service-based. In other words, such infrastructure assets are connected infrastructures which integrate mobility, technology, and green energy, all of which are key to effectively manage changes in consumer demand and to meet climate targets.

Infratech solutions can deliver value in various forms – be it enhanced quality to improved efficiency, longer operational life, sustainability, and more. The value derived can range from progressive (e.g., incremental benefits within the existing

[37] InfraVia. 'InfraVia launches Infravia Growth Fund and welcomes Alban Wyniecki, Guillaume Santamaria and François Auque.' November 1, 2019. https://infraviacapital.com/infravia-launches-infravia-growth-fund/

[38] LTIIA. 'Capturing the digital value of infrastructure – An interview with Vincent Levita, Founder and CEO of InfraVia Capital Partners.' October 16, 2019. https://www.ltiia.org/blog/capturing-the-digital-value-of-infrastructure-an-interview-with-vincent-levita-founder-and-ceo-of-infravia-capital-partners/#:~:text=Digital%20is%20transforming%20infrastructure%20business,revenues%2C%20reduce%20risks%20but%20a

[39] InfraVia. 'Infravia Capital Partners reaches objective and raises €501m for Growth Equity fund. January 25, 2022. https://infraviacapital.com/infravia-capital-partners-reaches-objective-and-raises-e501m-for-growth-equity-fund/#:~:text=25%20January%202022-,Infravia%20Capital%20Partners%20reaches%20objective%20and%20raises%20%E2%82%AC501m%20for,to%20the%20Tech%20B2B%20segment

[40] InfraVia's growth portfolio can be accessed here: https://infraviacapital.com/growth/

value chain) to disruptive (e.g., structural changes to the whole sector, for the better). There is no one-size-fits-all, and realising the optimal value case requires infrastructure investors to be imaginative.

More InfraTech use cases showing the value of outcomes and the typical commercial arrangements in which values can be captured or monetised are needed. This would allow decision-makers to include technology in their roadmaps.

For instance, fibre projects need to be built around an 'anchor tenant' which purchases part of the capacity, reducing the "overbuild" syndrome and corresponding demand risk (see Box 8). Data centres are another case in point, as they have emerged as the most in-demand asset, serving key storage and computing segments (e.g., non-AI, such as software as a service; internet and platforms as a service; enterprise; consumer apps; GenAI etc.). They provide an essential service which is unrelated to economic demand, and their very low churn rate is another advantage, as switching is expensive.

6.2.2. The need for a thorough risk/benefit analysis

Risk/benefit balance assessments are necessary for any InfraTech investment. Infrastructure investors must prepare for increased scrutiny from governments, local councils, power utilities, and ordinary citizens, and they need to maintain their 'social license to operate.'

For instance, when it comes to data centres, while they can provide stable income underpinned by relatively long leases which generally range from 5 to 10 years, infrastructure investors must be keenly aware that the large cloud service providers such as Amazon and Google prefer to own and operate their own data centres, making for a highly concentrated and competitive industry.

As such, funding capacity is not enough, and specialised development alongside technical and expertise, market analysis, and economies of scale are needed.

6.2.3. Portfolio approach

Lastly, InfraTech's benefits may be best realised at a portfolio level.

Many private investors still treat infrastructure as 'fixed income' asset that generates stable cash flow with little need for active management, similar to how PE and VC investors tend to behave. Historically, this hands-off treatment of infrastructure worked well, but it creates challenges when infrastructure sub-sectors face transformational changes. In such a context, infrastructure investors should increase their focus on technology growth opportunities to provide additional return- and risk management.

The benefits of using InfraTech solutions may not materialise in a single asset, given the high fixed costs and positive spillover effects across the sector. Technology applications may be more easily and effectively adopted at the portfolio level of infrastructure investors, as the costs of application in these cases are shared among projects and the benefits are greater as they aggregate across multiple projects. As such, economies of scale can be better pursued and achieved.

6.3. Cost control and de-risking

Value is not only generated from additional revenue generated by the technology but also from cost savings made possible by digitally-driven, better-informed decisions, and monitoring processes. In fact, InfraTech solutions can improve the efficiency of infrastructure investments by reducing cost overruns. Be it enhanced data management and communication or upgraded analytical functionality and communication flows, the cost-related benefits such solutions bring are significant. As a matter of fact, a 2017 study by the Inter-American Development Bank estimated that roughly 0.65% of the regional GDP of the Latin America and Caribbean region (around 22% of their total investment in infrastructure) could be saved by minimising cost overruns in infrastructure projects,[41] while a more recent World Bank reference note indicated that InfraTech solutions "are expected to deliver capital expenditure savings on the order of 10 percent and 20 percent."[42]

As for risks, investors aiming to invest in InfraTech to market beyond their own portfolio should recall that such solutions do not provide the kind of barriers to entry or captive market they may be used to in conventional infrastructure projects. Such investments rely on consumers who can choose between various providers, which hence brings forth a comparatively higher level of commercial uptake risk.

[41] Serebrisky, T. et al. 'Increasing the efficiency of public infrastructure delivery: Evidence-based potential efficiency gains in public infrastructure spending in Latin America and the Caribbean.' IDB. 2017. https://publications.iadb.org/en/increasing-efficiency-public-infrastructure-delivery-evidence-based-potential-efficiency-gains

[42] World Bank. 'InfraTech Value Drivers,' July 2020. https://openknowledge.worldbank.org/server/api/core/bitstreams/da58a2fa-a901-5dfa-9058-71b38cd21e53/content

In addition, InfraTech involves more distributed assets, as digital infrastructure assets are typically smaller and more geographically dispersed than traditional infrastructure assets, which can make managing the assets more challenging.

Box 12. Should InfraTech be considered its own separate asset class?

Whether InfraTech should be considered as an asset class separate from infrastructure is still up for debate.
But one thing is for sure: Digital infrastructure has become a staple in investors' portfolios and is widely assumed to deliver good returns – particularly given that data demand is forecast to grow exponentially in upcoming years, partly driven by the increasing adoption of AI solutions.

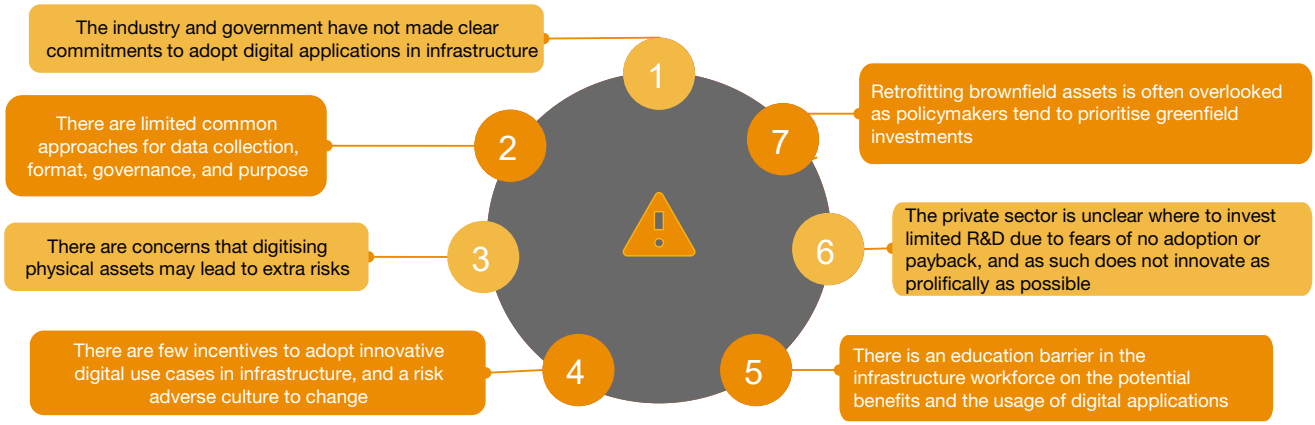
Data centres and the cloud can be considered to share several key features with conventional infrastructure, such as the provision of an essential service largely unrelated to economic demand, coupled with constrained supply due to insufficient power capacity in many jurisdictions. The 'churn' factor in these assets is also limited, as switching tends to be expensive.

Investors considering InfraTech solutions should be prepared for increased scrutiny from governments, local authorities, power utilities and ordinary citizens, particularly when such solutions can have a significant adverse impact on sustainability factors.

Risks and challenges to overcome

While InfraTech holds much promise to enhance infrastructure and contribute to solving some of the world's most pressing issues, it brings a host of risks and challenges that must be managed.

The diagram below provides an overview of the main barriers to InfraTech adoption:



In this section, we will briefly zoom in on some of the main barriers:

7.1. Implementation risks

Given the complexity and novelty of the underlying technologies, a potential risk for unintended adverse impacts on safety and reliability exists. Nascent technologies also carry additional risks due to greater technological uncertainty. Existing structures and policies by both the public and private sectors may not yet be ready to manage the complexity of procuring and rolling out InfraTech solutions.

7.2. Lack of policy support

The lack of clear commitment to InfraTech from both governments and the industry is another challenge. As a matter of fact, the absence of strong, unified leadership and policies which explicitly advocate for the integration of digital technologies in infrastructure projects is a significant hamper, as it leads to uncertainty and reticence among investors.

As a result, the InfraTech landscape becomes fragmented, whereby individual initiatives lack coordination and the necessary support to succeed on a larger scale. Few rewards are provided for those willing to take the risks of investing in and implementing new technologies, prompting many stakeholders to stick with proven methods rather than experiment with untested ones.

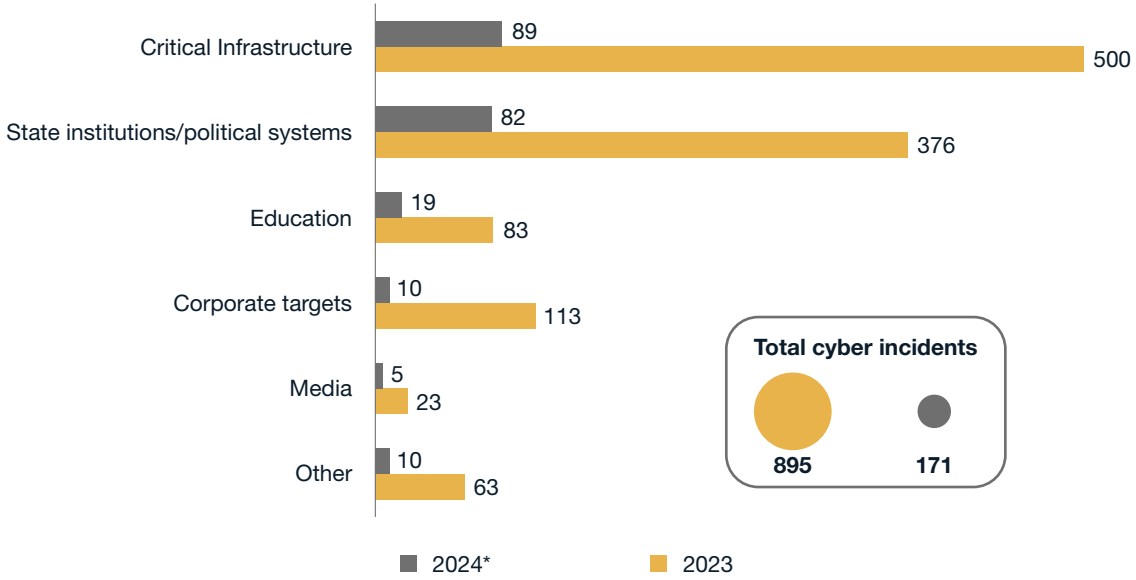
Meanwhile, governments generally tend to focus on new infrastructure projects when devising and implementing industrial policy, overlooking the substantial benefits that could be gained from upgrading existing assets with modern technologies. This focus on new developments neglects the opportunity to enhance the performance and longevity of existing infrastructure through digital retrofits.

7.3. Technology risks

When it comes to infrastructure, cyberattacks targeting transportation and power grids have led to disruptions, accidents, and economic losses globally. Given how technology has increasingly become interconnected with all aspects of our lives, such cyberattacks are only expected to continue and grow in scale.

Indeed, the proliferation of network connections in InfraTech systems has significantly expanded the risk of cyberattacks, which can have a catastrophic impact when implemented successfully on infrastructure systems. As Exhibit 17 below shows, cyberattacks targeting critical infrastructure – such as transportation networks, including air traffic control systems, railway networks, and traffic management systems – are among the top targets for hackers and cyber criminals.

Exhibit 17. Number of worldwide political cyberattacks aimed (by sector)



*Note: Data as of March 26, 2024.

Sources: *PwC Global AWM & ESG Research Centre; European Repository of Cyber Incidents*

Apart from the risks posed by cyberattacks, the risk of technological obsolescence – i.e., the possibility that the components, systems, or entire infrastructure becomes obsolete – complicates matters further. Should an infrastructure asset become ineffective, inefficient, or incompatible with evolving technological standards and requirements, this would significantly erode its value. The rapid evolution and constant advances of technology often run counter to the long-term investment horizons of capital projects and can lock investors into InfraTech projects that become outdated or no longer fit-for-purpose. As such, the risk of stranded and obsolete assets is very real.

Outdated technology can lead to inefficiencies and increased vulnerabilities, and this can negatively impact business operations, customer satisfaction, and competitiveness in the marketplace. Moreover, this could potentially make infrastructure more vulnerable to cybersecurity threats, including malware, data breaches, and cyberattacks.

Risks of obsolescence in the infrastructure industry

Costs of upgrading
Implementing technologies can be costly, but failing to upgrade them can lead to even greater long-term costs, such as lost productivity and revenue.

Compatibility issues
As technology evolves, newer systems may become incompatible with older hardware and software, causing significant integration issues.

Security risks
Older technology may not be equipped to handle the latest security threats, leaving business more vulnerable.

Competitive disadvantage
Failure to keep up with the latest security technology could leave businesses behind their competitors.

Environmental impact
Technology which is obsolete often results in electronic waste which can negatively impact the environment.

In addition, the long-term nature of infrastructure also means having to upgrade or retrofit technology into older networks, and doing so may significantly disrupt project parameters or result in large unplanned capital expenditures.

7.4. Resource scarcity and environmental risks

While existing solutions to decarbonisation are all founded on technological innovation, resource scarcity – such as power or water required to cool data centres – is already emerging as a formidable bottleneck to digitalisation. The growth of data centres has been relentless, and demand in the United States alone is projected to grow by 10% each year until 2030.[43] The growth prospects are particularly exponential for hyperscale data centres – the massive ones that provide extreme scalability capabilities[44] – as they provide a critical foundation to support the huge processing power required by AI and ML technologies.

Thus, infrastructure investors are under considerable pressure, both from governments and customers, to balance their decarbonisation targets with the need to stay at the top of cutting-edge technology.

7.4.1. The significant energy needs of data centres and GenAI

While there is no doubt that the digital transformation in general and the use of AI in particular could greatly facilitate the transition to a sustainable, fossil-free future (see Box 10), the huge appetite for electricity that comes from such technological innovations poses a significant challenge. In fact, concerns are mounting over whether there will be enough energy derived from clean sources to meet AI needs, on top of the needs of other sectors.

Although data centres have improved greatly in energy efficiency in recent years and have invested in clean energy to offset their carbon footprints,[45] they continue to be major energy consumers.

As for GenAI, the public rollout of ChatGPT in November 2022 marked a watershed moment for digital infrastructure and brought forth many discussions about the future of work and the technology's revolutionary potential – but few at the time paid close scrutiny to the energy costs associated with GenAI. In fact, the microchips underpinning AI use 3 to 4 times more power than traditional ones, and AI's energy consumption seems bound to overtake that of cloud systems globally. The rise in AI-driven energy demand is striking.[46]

According to the International Energy Agency's Electricity 2024 report "electricity consumption from data centres, artificial intelligence (AI) and the cryptocurrency sector could double by 2026," and the electricity demand of data centres could reach 1,000TWh in 2026 – a demand "roughly equivalent to the electricity consumption of Japan." The IEA expects data centres to account for a third of new electricity demand in America over the next two years. By the end of the decade AI data centres could consume as much as a quarter of all American electricity, up from 4% or less today.[47]

Such an exponential increase in energy consumption will require substantial additional energy capacities, both in renewable power generation and in grid expansion – two undertakings that are costly, cumbersome, and time-consuming, as our previous report on the energy transition highlighted.[48]

In some jurisdictions, such as Ireland, public grid operators are no longer accepting new permits or requests for connection by data centres.[49] In others, utilities are bracing themselves by resorting to new gas or coal-powered generating facilities.

[43] Schaap, A. 'Booming Data Center Economy In 2024 (And Why Investors Are Taking Notice).' Forbes. January 22, 2024. https://www.forbes.com/sites/forbestechcouncil/2024/01/22/five-trends-driving-the-booming-data-center-economy-in-2024-and-why-investors-are-taking-notice/#:~:text=I'm%20talking%20about%20the,new%20facilities%20hitting%20%2449%20billion

[44] Powell, P. & Smalley, I. 'What is a hyperscale data center?' IBM. March 21, 2024. https://www.ibm.com/topics/hyperscale-data-center#:~:text=A%20hyperscale%20data%20center%20is,network%20connectivity%20and%20minimized%20latency

[45] The Economist. 'Data centres improved greatly in energy efficiency as they grew massively larger.' January 28, 2024. https://www.economist.com/technology-quarterly/2024/01/29/data-centres-improved-greatly-in-energy-efficiency-as-they-grew-massively-larger

[46] The Economist. 'Generative AI has a clean-energy problem.' April 11, 2024. https://www.economist.com/business/2024/04/11/generative-ai-has-a-clean-energy-problem

[47] IEA. 'Electricity 2024: Analysis and forecast to 2026.' May 2024. https://iea.blob.core.windows.net/assets/18f3ed24-4b26-4c83-a3d2-8a1be51c8cc8/Electricity2024-Analysisandforecastto2026.pdf

[48] LTIIA. 'Energy Transition: Implications for Infrastructure Investors.' October 2023. https://www.ltiia.org/wp-content/uploads/2023/10/Energy-Transition-Report-Final-Web-Version.pdf

[49] Swinhoe, D. 'EirGrid says no new applications for data centers in Dublin until 2028 – report.' Data Center Dynamics. January 11, 2022. https://www.datacenterdynamics.com/en/news/eirgrid-says-no-new-applications-for-data-centers-in-dublin-till-2028/

In the United States for instance, Georgia Power – the southern state's electric utility – recently received approval "to generate 1.4GW from three new natural gas or oil-burning generators, as well as solar battery energy facilities" to meet the energy "demands driven by industrial sites and data centers."[50]

While the obvious solution would be to make AI servers more energy-efficient, the 'rebound effect' means that more efficient chips could inadvertently have adverse energy impacts by simply stimulating more usage.

Another option would be for the 'hyperscalers' to use their financial resources to help utilities overcome some of the grid constraints by having small power plants on standby. However, such power plans are likely to be fuelled by natural gas, which would undermine cloud providers' climate commitments.

What's also problematic is that the environmental costs go beyond energy. The increased data storage requirements of many InfraTech solutions generate increased waste and water consumption. For instance, data centres require industrial-grade air-conditioning systems to cool the servers, which brings about significant water consumption, while some InfraTech solutions rely on scarce natural resources (e.g., lithium) whose extraction could bring about adverse environmental and social repercussions throughout the supply chain.

For now, a way through which infrastructure investors can preserve the value of their investments is by being proactive in mitigating the adverse environmental consequences of the data centres. This can be done by designing data centres in a way which not only maximises energy efficiency but can also be retrofitted over time with state-of-the-art technology and upgraded during refresh cycles. Alternatively, the Cloud has the potential to decrease carbon emissions in IT. Migrating applications to the cloud and shutting down data centers could significantly reduce IT carbon emissions since cloud service providers tend to run highly efficient data centers on renewable energy.

Box 13. Case Study: Supporting local economies and driving the digital transformation in Africa with Raxio's sustainable data centres

In March 2021, infrastructure investor Meridiam partnered with Roha Africa to jointly develop "a platform of carrier-neutral, co-location data centres of international (Tier III) standard across Africa."[51] The 'Raxio' brand was born, and the Raxio Group is now the leading data centre operator in Africa. The state-of-the art, environmentally-friendly investment is made in the context of the African economies leapfrogging and becoming increasingly digitalised thereby driving up the demand for the use of data centres, while available local capacity remains under-developed.

What distinguishes the firm from other operators is that its data centres incorporate several sustainability and ESG measures. Environmental sustainability achievements include maximising energy, carbon, and water efficiencies, with a high Power Usage Effectiveness (PUE) ratio of 1.3-1.35, alongside the integration of hydro, solar, and other renewables into the energy mix, and a low-carbon development charter.

Raxio's state-of-the art, environmentally-friendly data centres seek to propel the digital transformation of African economies and drive up demand for and usage of data centres.

[50] Butler, G. 'Georgia Power increases power capacity by 1.4GW with fossil fuels to meet data center demand.' Data Center Dynamics. April 17, 2024. https://www.datacenterdynamics.com/en/news/georgia-power-increases-power-capacity-by-14gw-with-fossil-fuels-to-meet-data-center-demand/#:~:text=In%20a%20vote%20that%20passed,warning%20from%20clean%20energy%20groups

[51] Meridiam. 'Raxio data centres, pan-African.' https://www.meridiam.com/assets/raxio-data-centres/

7.5. Societal risks

InfraTech solutions bring forth a host of societal benefits. According to the GI Hub, it "can enhance the social inclusion of infrastructure services and create new jobs and economic opportunities by connecting people with jobs and creating new, technology-driven industries and markets." In addition, "it can broaden access to essential social services and make accessing these services more reliable, thereby improving the inclusivity of infrastructure."[52]

However, within the broader umbrella of ESG risks, certain InfraTech solutions could pose significant societal risks, and politicians and utilities may be tempted to pin the blame on data centres.

Uneven rollout of InfraTech solutions may exacerbate the digital divide when it comes to accessing technologies and infrastructure services. For instance, as InfraTech solutions get rolled out in urban environments and enhance the quality of infrastructure there, rural areas may end up feeling neglected, thus amplifying the urban-rural digital divide.

The exponential increase in data generated through InfraTech poses societal and technical challenges, including heightened cybersecurity risks and issues related to data privacy, protection, and confidentiality.

As with any industrial revolution, the adoption of new technologies in the infrastructure sector could result in labour/skill mismatches and disruptions in the job market. Technology-driven unemployment is a real risk, as jobs may be lost to automation. In particular, GenAI, despite being easier to use and less impactful in terms of digital divide, will still affect some jobs more than others, requiring certain workers to adapt while others may see their roles taken over.

7.6. Geopolitical risks

The geopolitical dimension surrounding digital infrastructure cannot be ignored, particularly given how the current fractured global geopolitical and economic landscape[53] has been described with labels such as 'polycrisis' or 'perma-crisis.'

Reconciling the concepts of national sovereignty with the borderless and universal nature of the digital space in which data flow can be tricky, and national attempts to achieve digital sovereignty could come at the expense of global technological development and market opportunities. Indeed, controversy is widespread among the main global players and a level playing field is far from being agreed upon.

As the world's largest economic and political heavyweights, the United States and China are the main rivals in the competition for technological leadership. The EU has sought to strike a balance between the two and has more recently begun stressing the importance of progressively becoming a digital and technological powerhouse. To that effect, the European Commission has adopted several overarching industrial strategies and policies – such as the European Chips Act[54] and the Net-Zero Industry Act,[55] to name a few – to increase the continent's digital and technological strategic autonomy.[56]

As such, infrastructure investors considering InfraTech solutions should always keep in mind this geopolitical backdrop before embarking on any endeavour, no matter how promising and enticing it may be, so that they can be well-prepared to deal with any unforeseen repercussions.

[52] GI Hub. 'InfraTech.' https://infratech.gihub.org/

[53] PwC. 'From Compliance to Competitive Advantage: Risk and Performance in a Fractured World.' February 26, 2024. https://www.pwc.lu/en/regulatory-compliance/risk-performance-in-a-fractured-world.html

[54] European Commission. 'European Chips Act.' https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en

[55] European Commission. 'The Net-Zero Industry Act: Accelerating the transition to climate neutrality.' https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en

[56] Secchi, C. and Gili, A. 'Digitalisation for Sustainable Infrastructure: The Road Ahead.' ISPI. October 5, 2022. https://www.ispionline.it/en/publication/digitalisation-sustainable-infrastructure-road-ahead-36357

Conclusions and recommendations

As our world stands at the crossroads of unprecedented global challenges and technological advancement, InfraTech stands as a powerful catalyst for transformative change in the infrastructure sector.

By integrating cutting-edge technologies into infrastructure systems, a path towards addressing climate change, rapid urbanisation, resource scarcity, and social inequalities while advancing sustainability and broader ESG goals is set. As it has the potential to enable smarter, more efficient, and sustainable infrastructure, InfraTech can effectively revolutionise how infrastructure assets are built and managed for the better.

Adopting InfraTech solutions is no longer a mere technological imperative but a strategic necessity for the public and private sectors. InfraTech can bridge the infrastructure investment gap: Such solutions can significantly contribute to achieving the UN SDGs and the objectives of the Paris Agreement, enhancing resilience to climate-related risks, and improving the quality of life for countless people.

Moreso, InfraTech solutions play an important role from both the demand and supply side. Regarding demand, InfraTech can reduce cost overruns, while for supply, it enables investors to mobilise more private capital and de-risk their investments, by providing data and analytics to better quantify and assess risks and costs.

However, achieving the promise and full potential of InfraTech will require substantial efforts and investments, and several key considerations need to be addressed.

As highlighted in Exhibit 2, a minimum of USD 3.7tn in infrastructure investments is needed in 2024 globally to support SDGs, compared to the projected USD 2.9tn that will be mobilised. Even a limited savings of 10% provided by InfraTech solutions would go a long way towards bridging this gap.

While the public sector alone cannot be expected to close this substantial funding gap, it can play a key role in enabling further scaling up of private investments into InfraTech. With its extensive experience in infrastructure investment, private capital is ideally suited to help bridge this gap. However, this does not mean that the public sector has no role to play to enable further scaling up of private investments into Infratech through:

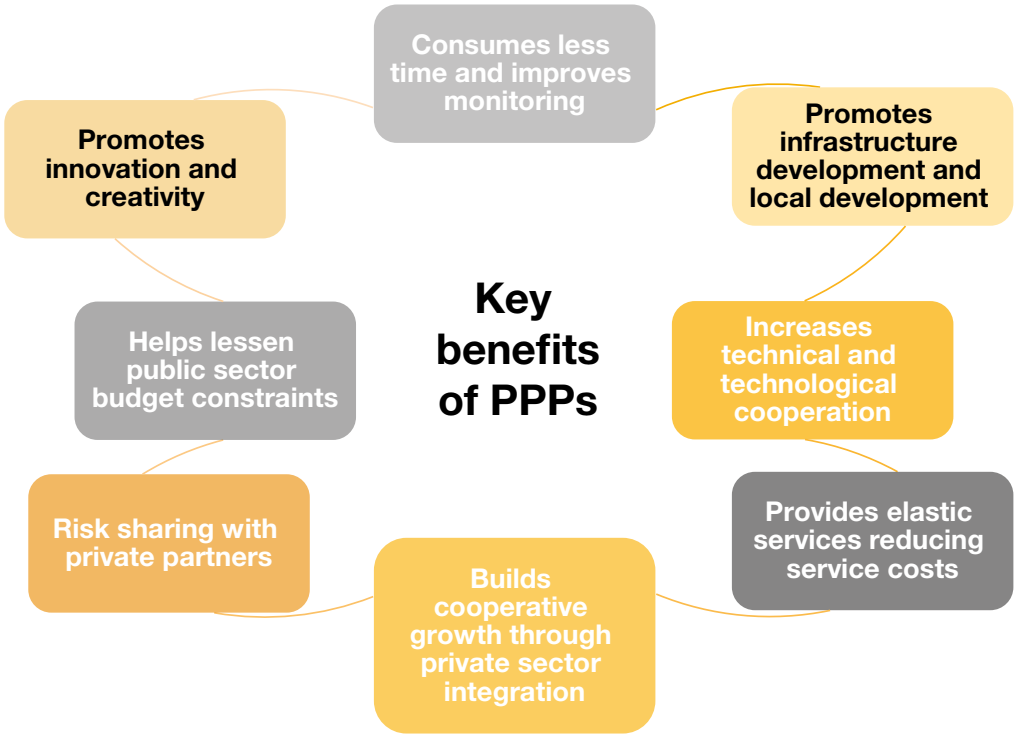
Adapted procurement tools and delivery models

The infrastructure sector in most jurisdictions is hampered by top-down planning processes and highly constrained procurement arrangements which leave little room for process innovations or flexibility in the architecture of a program or project. Procurement of technologies usually require a process that is more collaborative and outcome-based, while public contracts often tend to be disconnected and highly specific, which limits collaboration and potential outcomes.

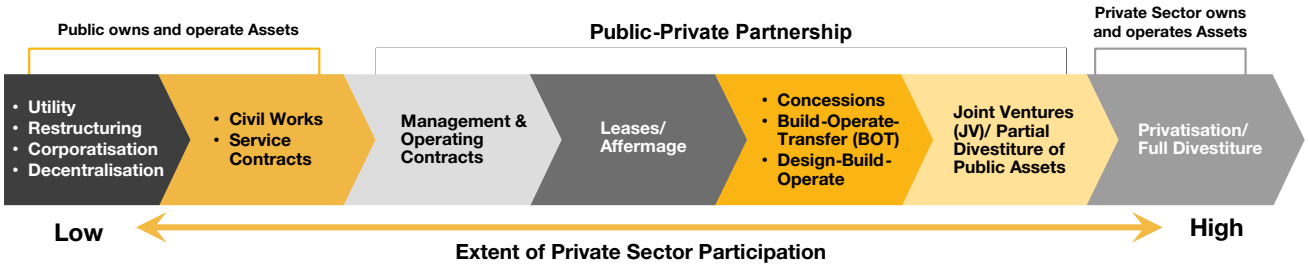
An alternative, outcomes-based contracting approach would be able to deliver much more. This calls for more and better public-private collaboration whereby innovative procurement approaches and delivery models would be adopted, hence incentivising the incorporation of InfraTech solutions into projects at all stages of the lifecycle.

In particular, Public-Private Partnerships (PPPs) can be used for leveraging private sector innovation to develop cutting-edge solutions within a stable and well-defined framework. Well-structured PPPs designed for digital infrastructure and technology can provide maximum benefits when diverse stakeholders collaborate, combining their strengths to bring the next generation of infrastructure to life, while responsibly managing public resources and ensuring that adequate risk management frameworks are in place.

The diagram below illustrates the key benefits of PPPs when the right contractual balance is achieved:



However, PPPs aren't a panacea, and PPP contracts have in many instances proven to be too rigid to keep up with technological disruptions, hampering their capacity to address and spread innovative solutions.



Private investments significantly contribute to expanding technological innovation within the infrastructure sector, particularly in primary deals such as greenfield projects. The resurgence of private investment in infrastructure in 2022, surpassing pre-pandemic levels, underscores its importance. However, the subsequent decline in capital raised in 2023 highlights ongoing challenges, including disparities between high-income and lower-income countries. Elevated risk premiums and the impact of climate change on infrastructure valuations are a further challenge hampering the wider deployment of InfraTech solutions.

This is why governments should actively engage in PPPs, not only to leverage additional capital, but also to address private investors' expectations for return on investment, which must be factored into PPP pricing strategies. Enhancing infrastructure pricing to incorporate construction, maintenance, and repair costs can promote efficiency by encouraging the refurbishment and reuse of existing infrastructure over the construction of new projects.

Adapted regulatory frameworks:

But governmental authorities' role doesn't end here. By establishing a clearer, structured, and uniform regulatory frameworks well-adapted to encourage the incorporation of technology into infrastructure, governments can create a safer environment for private investors, fostering increased investments in InfraTech.

Infrastructure is an unnecessarily complex asset class, but data and digitalisation can simplify investment processes and bring much-needed transparency – and many long-time infrastructure players are breathing a sigh of relief now that digital transformation is finally making its way to the sector.

Looking ahead, the future of InfraTech looks promising. As technologies continue to evolve and converge, and as investment flows towards firms engaged in InfraTech solutions continue to pick up steam, innovative solutions will continue to emerge. Information asymmetry will be reduced, and industry stakeholders will be empowered with the data needed to inform critical decisions, further contributing to the creation of resilient, sustainable, and inclusive infrastructure that meets the needs of current and future generations.

In conclusion, InfraTech represents nothing less than a paradigm shift in infrastructure development and management. By embracing this technological revolution, the opportunity to build a more sustainable, resilient, and prosperous world is at hand. This will require a higher risk appetite, a longer time horizon, and specialised industrial skills. A thorough understanding of current socioeconomic challenges and how technology can effectively address them is a must. InfraTech is not just about providing solutions but ensuring that they align with broader public benefit and policy goals.

Moving forward, it is imperative that policymakers, industry leaders, investors, and all stakeholders work together to harness the power of InfraTech and drive meaningful progress towards solving the pressing socioeconomic and environmental challenges of our times. InfraTech will be a game-changer, and the opportunity is here. It is on us to seize it.

Appendix 1
LTIIA's internal InfraTech survey

We launched an internal survey with members of the LTIIA working group to get a snapshot of the thoughts and views of infrastructure investors' over on InfraTech. Bearing in mind that the sample of respondents is small and that no generalisable claims can or should be made, this appendix provides the key takeaways from the survey:

- Respondents generally converge on what should be included within the scope of InfraTech, namely digital infrastructure assets (e.g., data centres; IoT) alongside soft digital assets and services (AI, big data, cloud computing tools, blockchain, AR and VR, predictive maintenance tools etc.).

- Over two-thirds of respondents (71%) believe that InfraTech should not be considered as a separate asset class, distinct from traditional infrastructure. In addition, over half of respondents (57%) see infrastructure investors' role as being mostly complementary with that of VC and PE investors. Overall, there is a consensus among respondents that infrastructure investors should harness InfraTech assets by seeing them less as a separate potential field of investment, and more as a potential to improve existing traditional infrastructure assets investment.

- Around 7 in 10 respondents believe that InfraTech's potential is highest in the early development and the operations and maintenance stage of the infrastructure lifecycle. Half of respondents expect InfraTech investments to bring about a changing risk/return profile, geared to increase returns and lower risks.

- Most respondents (71%) already have InfraTech as part of their investment strategy, and it tends to be mostly applied to energy transition assets. However, only one-third (33%) consider that they already have adequate access to relevant data informing their InfraTech investment decisions.

- Respondents believe that cybercrimes and fraud are the biggest risks associated with InfraTech, while regulations and political intervention risks are of the least concern.

Appendix 2
Ranking of top InfraTech investors by transaction value

The following tables and their accompanying short commentaries present the top InfraTech investors based on different criteria and investor type. The data presented has been extracted from IJ Global and covers the whole period between 2015 and H1 2024.

Table 4. Top 10 InfraTech investors in Infrastructure assets per deal size (global)

#	Player	Total Transaction Value (USD bn)	N. of deals	Type of Investor	Country
1	CITYFIBRE	36.5	7	Infrastructure Developer	
2	AMTRAK	16.4	1	Institutional Player	
3	OPEN FIBER	10.2	2	Infrastructure Developer	
4	STACK INFRASTRUCTURE	9.4	12	Infrastructure Developer	
5	QTS REALITY TRUST	7.1	12	Infrastructure Developer	
6	VANTAGE DATA CENTERS	6.2	15	Infrastructure Developer	
7	INFRATEL ITALIA	5.1	1	Infrastructure Developer	
8	ASCENTY	4.6	5	Infrastructure Developer	
9	ALIGNED DATA CENTERS	4.6	5	Infrastructure Developer	
10	STONEPEAK	4.3	2	GP	

Recent data indicates a global surge in investment by infrastructure developers into primary InfraTech deals, including greenfield and brownfield projects. In 2022, total investment in InfraTech projects reached a record USD 62.8bn, followed by USD 47.4bn in 2023. Leading the global investment landscape is the British telecommunications network provider CityFibre, which emerges as a primary InfraTech investor with a total transaction value of USD 36.5bn. Other notable players include Amtrak and Open Fiber, with investments of USD 16.4bn and USD 10.2bn, respectively. These significant contributions underscore the growing momentum and importance of InfraTech investments worldwide.

Appendix 2

Table 5. Top 10 InfraTech investors in Infrastructure assets per deal size (GPs)

#	Player	Total Transaction Value (USD bn)	N. of deals	Country
1	STONEPEAK	4.3	2	
2	BLACKSTONE	2.6	6	
3	IPI PARTNERS	2.3	7	
4	BLACKROCK	1.7	1	
5	SDC CAPITAL PARTNERS	0.9	1	
6	SIXTH STREET	0.6	3	
7	VAUBAN INFRASTRUCTURE PARTNERS	0.5	2	
8	QUAERO EUROPEAN INFRASTRUCTURE FUND	0.5	3	
9	EQT PARTNERS	0.5	2	
10	EMPYRION	0.5	2	

Among GPs, the top InfraTech player is Stonepeak which closed 2 deals amounting to a total transaction value of USD 4.3bn, followed by Blackstone which completed 6 deals between 2015 and H1-2024 for a total transaction value of USD 2.6bn. Other players in the segment include IPI Partners and Blackrock, as both of them participated in deals that crossed the USD 1.5bn threshold during the period considered.

Appendix 2

Table 6. Top 10 InfraTech investors in Infrastructure assets per deal size (energy firms*)

#	Player	Total Transaction Value (USD bn)	N. of deals	Country
1	ADANI ENTERPRISES	1.7	6	
2	ELDRIVE	0.5	3	
3	IBERDROLA GROUP	0.3	1	
4	OCP GROUP	0.3	1	
5	SK ECOPLANT	0.2	1	
6	UDENNA	0.1	1	
7	EWE AG	0.08	1	
8	HYDRO-QUÉBEC	0.08	1	
9	ENERGIEVERSORGUNG OFFENBACH	0.06	1	
10	OMV PETROM	0.05	1	

*Note: Energy firms are identified as companies involved primarily in the production and distribution of energy.

Among energy firms, Adani, the Indian multinational group, concluded the largest share of deals by transaction value among energy players. From 2015 to mid-year 2024, its total deal size reached USD 1.7bn. Other notable players in the energy sector include Eldrive, Iberdrola, OCP, and SK Ecoplant, with total transaction values ranging from USD 200mn to USD 500mn in the period considered. With the sole exception of Adani, the number of InfraTech deals among energy firms is generally low, with most firms engaging in just one or two deals.

Appendix 2

Table 7. Top 10 InfraTech investors in Infrastructure assets per deal size (institutional players)

#	Player	Total Transaction Value (USD bn)	N. of deals	Country
1	AMTRAK	16.4	1	
2	GOVERNMENT OF IRELAND	3.4	2	
3	AUSTRALIANSUPER	1.1	2	
4	CAISSE DES DEPOTS ET CONSIGNATIONS	1.0	8	
5	GOVERNMENT OF FRANCE	0.8	1	
6	FONDS D'INVESTISSEMENT ET DE DEVELOPPEMENT DES PARTENARIATS PUBLIC-PRIVE 2	0.6	2	
7	MINISTRY OF TRANSPORTATION AND COMMUNICATIONS	0.3	1	
8	GOVERNMENT OF ANGOLA	0.2	1	
9	DEFENCE CONSTRUCTION CANADA	0.2	1	
10	GOVERNMENT OF INDONESIA	0.2	1	

In terms of investments, the National Railroad Passenger Corporation (Amtrak) in the United States has the highest total transaction value in InfraTech primary deals, despite only completing a single transaction in the 2015-H12024 period worth USD 16.4bn. The Government of Ireland participated in two deals during this period, for a total amount of USD 600mn. Primary deals activity by other sovereign wealth funds or multilateral development banks is more marginal, with a total transaction value less than USD 100mn.

Appendix 2

Table 8. Top 10 InfraTech investors in Infrastructure assets per deal size (infrastructure developers)

#	Player	Total Transaction Value (USD bn)	N. of deals	Country
1	CITYFIBRE	36.5	7	
2	OPEN FIBER	10.2	2	
3	STACK INFRASTRUCTURE	9.4	11	
4	QTS REALTY TRUST	7.1	12	
5	VANTAGE DATA CENTERS	6.2	15	
6	INFRATEL ITALIA	5.1	1	
7	ASCENTY	4.6	5	
8	ALIGNED DATA CENTERS	4.6	5	
9	ECHELON DATA CENTRES	3.9	6	
10	EQUINIX	3.6	9	

Among InfraTech investors, the largest primary deals targeting other infrastructure developers were executed by CityFibre and Open Fiber, with deal values of USD 6.6bn and USD 4.2bn, respectively. Plus Power and Aypa Power are also active investors, each completing six InfraTech deals for a total value of USD 1.6 bn and USD 0.4 bn, respectively. Other relevant players are QTS Realty Trust, Community Fibre and Echelon Data Centres, all completing a single transaction valued at USD 1bn or more.

Appendix 2

Table 9. Top 10 InfraTech investors in Infrastructure assets: Europe

#	Player	Total Transaction Value (USD bn)	N. of deals	Country
1	CITYFIBRE	36.6	7	
2	OPEN FIBER	10.2	2	
3	INFRATEL ITALIA	5.1	1	
4	ECHELON DATA CENTRES	3.9	6	
5	GOVERNMENT OF IRELAND	3.4	2	
6	BOUYGUES	2.4	2	
7	ALTITUDE	2.1	8	
8	PULSANT	1.6	10	
9	CAISSE DES DEPOTS ET CONSIGNATIONS	1.0	8	
10	ADTIM	0.9	2	

Europe stands out as a key region for investors focused on InfraTech primary deals. Leading the charge is CityFibre, the aforementioned British telecommunications network provider, which tops the list of investors in Europe with a total transaction value of USD 36.6bn. Additionally, two infrastructure developers have emerged as prominent players in the European InfraTech landscape: Italy's Open Fibre, with investments totalling USD 10.2bn, and Infratel Italia, with a total transaction value of USD 5.1bn. These significant investments underscore the strong interest and commitment to advancing infrastructure technology in Europe.

Appendix 2

Table 10. Top 10 InfraTech investors in Infrastructure assets: North America

#	Player	Total Transaction Value (USD bn)	N. of deals	Type of Investor	Country
1	AMTRAK	16.4	1	Institutional Player	
2	STACK INFRASTRUCTURE	9.4	12	Infrastructure Developer	
3	QTS REALITY TRUST	7.1	12	GP	
4	VANTAGE DATA CENTERS	6.2	15	Infrastructure Developer	
5	ALIGNED DATA CENTERS	4.6	5	Infrastructure Developer	
6	STONEPEAK	4.3	2	GP	
7	EQUINIX	3.6	9	Infrastructure Developer	
8	EDGECONNEX	3.1	11	Infrastructure Developer	
9	DATABANK	2.7	4	Infrastructure Developer	
10	BLACKSTONE	2.6	6	GP	

The United States hosts the majority of investors keen on InfraTech investment, particularly in primary deals. The top three investors in North America are all based in the US, underscoring the country's dominance in this sector. Leading the pack is Amtrak, amassing a transaction value of USD 16.4bn. While the major InfraTech investors in North America are primarily infrastructure developers, notable exceptions exist. For instance, Blackstone stands out as one of the largest investors, with a total transaction value of USD 2.6bn. These significant investments highlight the pivotal role of US-based firms in driving the growth and development of InfraTech on a global scale.

Appendix 2

Table 11. Top 10 InfraTech investors in Infrastructure assets: Asia-Pacific

#	Player	Total Transaction Value (USD bn)	N. of deals	Type of Investor	Country
1	KDDI	3	3	Infrastructure Developer	
2	ADANI ENTERPRISES	1.7	6	Energy Firm	
3	PRINCETON DIGITAL GROUP	1.3	2	Infrastructure Developer	
4	MAXIS COMMUNICATIONS	1.1	2	Infrastructure Developer	
5	AUSTRALIANSUPER	1.1	2	GP	
6	AIRTRUNK	0.8	5	Infrastructure Developer	
7	SINGAPORE TELECOMMUNICATIONS	0.8	5	Infrastructure Developer	
8	LENDLEASE	0.8	2	Infrastructure Developer	
9	RELIANCE INDUSTRIES	0.7	1	Infrastructure Developer	
10	KEPPEL DC CREDIT	0.7	6	Bank/Financial Institution	

The APAC region showcases a diverse range of InfraTech investors. Among the major players are Japan's KDDI, India's Adani, and Singapore's Princeton Digital Group, all of which are making significant strides in InfraTech investments. However, the scale of investments in the region is noticeably smaller than in North America and Europe. In fact, almost all the top InfraTech investments in by APAC players do not exceed the billion-dollar mark, highlighting a more modest investment landscape. This variety in investor types underscores the dynamic and evolving nature of the InfraTech sector in APAC, driven by both traditional infrastructure developers and influential financial institutions, which could help the region in reaching its European and American counterparts.

Appendix 2

Table 12. Top 10 InfraTech investors in Infrastructure assets: Middle East and Africa

#	Player	Total Transaction Value (USD bn)	N. of deals	Type of Investor	Country
1	RAXIO GROUP	1.2	7	Infrastructure Developer	
2	AFRICA DATA CENTERS	0.3	1	Infrastructure Developer	
3	OOREDOO	0.3	1	Infrastructure Developer	
4	OCP GROUP	0.3	1	Energy Firm	
5	GOVERNMENT OF ANGOLA	0.2	1	Institutional Player	
6	OMAN BROADBAND	0.2	1	Infrastructure Developer	
7	ANGOLA CABLES	0.2	2	Infrastructure Developer	
8	PARATUS	0.1	4	Infrastructure Developer	
9	OCTOTEL	0.1	1	Infrastructure Developer	
10	SMART AFRICA ALLIANCE	0.1	1	Institutional Player	

The Middle East and Africa region has the highest variety of players in term of investors' domicile. The largest transactions were concluded by Raxio Group (Uganda) and Africa Data Centers (South Africa), two infrastructure developers, and valued respectively at approximately USD 1.2bn, and USD 300mn. Additionally, Qatar's InfraTech company Ooredoo completed one transaction valued at USD 300mn.

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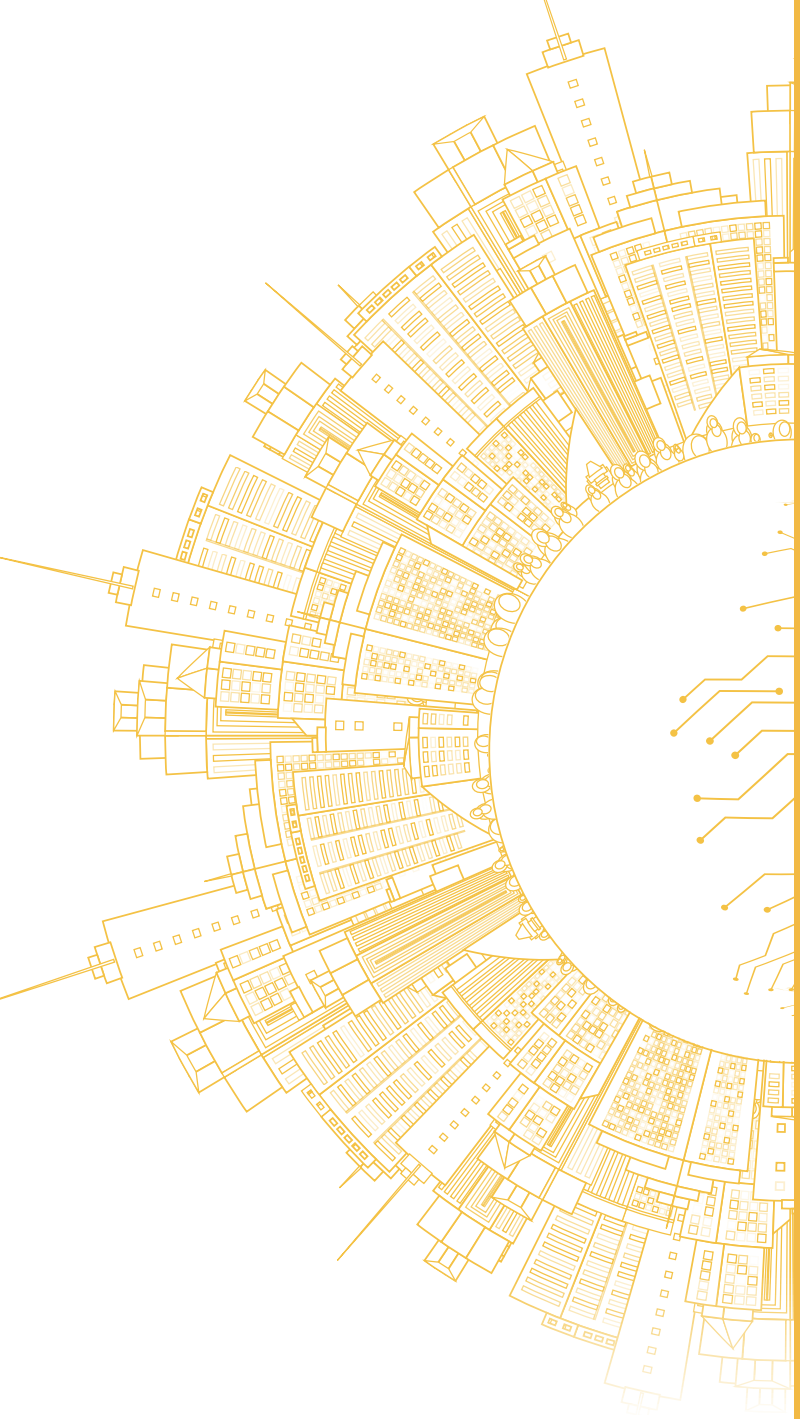
Glossary

3D Printing	Companies involved in the process of, or making of, three dimensional solid objects from a digital file. Sometimes referred to as additive manufacturing (AM) as well as computer numerical control (CNC).
Artificial Intelligence (AI)	Companies that design and provide computer systems that perform tasks that normally require human intervention/ intelligence including Autonomous Vehicle, Chat bots, Deep Learning and Machine Learning.
Augmented Reality (AR)	Companies involved in AR typically provide hardware, software, and content development for AR applications in order to superimpose a computer-generated image onto a user's view of the real world.
Big Data	Companies engaged in providing solutions for large volumes of data, both structured and unstructured. Solutions are provided for data gathering, storing, and analysis. Including Click-Stream Data, Financial Data, Input Data, Point of Sale Data, Sensor Data, and Web Log Data.
Blockchain	Companies involved in providing the systems required to build or maintain cryptographic ledger systems that are typically decentralised, distributed and public. Including File/Cloud Storage, Identity Management, Smart Contracts.
Clean technology (CleanTech)	Companies engaged in providing processes, products or services that reduce negative environmental impact through significant energy efficiency improvements, the sustainable use of resources, or environmental protection activities.
Cloud computing	Companies involved in the provision of services to create and maintain remote servers hosted in the Internet to store, manage and process data. Including Data as a service (DaaS), Infrastructure as a service (IaaS), Platform as a service (PaaS), and Subscription as a service (SaaS).
Financial services	Companies that provide financial and economic services with the aim of managing money.
InfraTech	Any new or innovative technology (physical or digital) applied to infrastructure with the aim of achieving step-change efficiency and impact toward economic, social or environmental objectives.
Internet	Companies that provide products and services to support or develop internet-based infrastructure.
Internet of Things (IoT)	Companies involved in the creation and development of products and services that extend Internet connectivity to physical devices and everyday objects. Examples include Edge Computing, Smart Cities, and Smart Grids.
InsureTech	Companies engaged in the provision of technology across the insurance value chain. Examples include peer-to-peer insurance, online brokerage platforms, cyber insurance, underwriting/quote platforms, and other related solutions.
IT security/cybersecurity	Companies engaged in the protection of IT systems. Includes protection against unauthorised access or malicious cyber-attacks.
Real Estate Tech	Companies engaged in the provision of technology specific to the property/real estate industry, including investment management and execution and asset management. Examples include property management software, real estate data and analytical tools, VR home shows, design applications, and more.
Software	Companies that develop, maintain and publish software predominantly through license or cloud-based models.

Notes

Notes



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