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A comparison of the present growth pace of the United States infrastructure with the needs of the next decade (2025-2050)

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Abstract

The US population relies on crumbling infrastructural facilities needing continual upkeep. As economic activity accelerates with purchasing power projected at more than $34.102 trillion (about $100,000 per person) compared to $16.7 trillion (about $51,000 per person) today, with the US population experiencing rapid growth with a projected population of over 438 million by 2050 compared to 350 million today, infrastructural development will be significantly affected. This study considers how human interactions and recent developments (the Covid-19 outbreak and the development of artificial intelligence) will bring about change in the future demand for infrastructure in the US by 2045.

Keywords: Infrastructure; Public Asset; Technology; Private assets; Public assets; Technology; Population growth

1. Introduction

The appalling state of the US infrastructure and public assets is a major cause of concern to US leaders and stakeholders (Kiger, 2021; Puentes, 2015). The need to address the deteriorating conditions of the US public assets has become a contentious subject that has not only generated intense debate among the public but has also drawn the attention of policymakers, including those in the highest echelon of power in the country: the senate and the presidency (Kiger, 2021).

Since the United States is the largest economy in the world, and the economic expansion and growth of any nation usually depends on the level of her infrastructural development, it is highly anticipated that the US should logically lead the world with its pace of infrastructural development. Unfortunately, that is not the case (Kane and Tomer, 2019; Puentes, 2015; World Economic Forum, 2019). The fact that the US lags behind several nations in infrastructural provision in the annual ranking by the World Economic Forum is a paradox, given that she leads these nations in the global economy (Kane and Tomer, 2019; World Economic Forum, 2019).

People frequently hold the view that aging infrastructure, rising population, politics, and technological development are to blame for why the US is not leading the world in infrastructure development. Some people even think that the US is still living in its heyday since we lag in terms of housing, water quality, and train infrastructure. President Biden's infrastructure plan, which is expected to cost $2.25 trillion (about $6,900 per person in the US), includes a significant investment in transportation infrastructure, with $621 billion (about $1,900 per person in the US) allocated to upgrading and building bridges and road networks. Other major areas of focus include upgrading the national grid ($100 billion or about $310 per US citizen), investing in housing ($213 billion or about $660 per person), expanding internet broadband ($100 billion), investing in workforce development ($100 billion), and upgrading water infrastructure ($111 billion or about $340 per person). The plan aims to renew and build new infrastructure across the country (Whitehouse.gov, n.d.). Administrations frequently ignore research and development (R&D), a crucial component of

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infrastructure development. By using 21st-century methods that emphasize environmental protection, cost-effectiveness, high performance, and data collection for operation and maintenance, R&D can assist in updating outmoded infrastructure. The sustainability, efficiency, and efficacy of sustainable infrastructure systems may all be improved with the aid of these strategies, which will eventually result in considerable cost savings. Governments may guarantee that their infrastructure projects are based on the most recent information and technology and are better prepared to fulfill the needs of the 21st century by investing in R&D (Dove and George, 2018).

Many stakeholders, opinion leaders, and policymakers have begun intensifying efforts geared toward addressing the worsening situation of US public assets (Kane and Tomer, 2019; McBride and Siripurapu, 2021; McKinsey & Company, 2020; Puentes, 2015). The primary focus of this study is determining the underlying reasons for this issue and outlining solutions. A lack of R&D funding is a main cause of outdated infrastructure. The issue has also been exacerbated by a lack of long-term planning and a failure to match infrastructure investments to the nation's needs.

The study proposes that significant funding for R&D is required to update and put 21st-century methodologies into practice that focus on cost-effectiveness, high performance, and data collection for operation and maintenance to address these concerns. It is necessary to develop a long-term vision and plan for infrastructure to ensure that investments in infrastructure are aligned with the country's long-term goals and aspirations.

This study's research gives a thorough overview of the issue and points to important areas for development. If adopted, the suggested remedies might have a substantial impact on the current condition of US public assets and support ongoing efforts to alleviate the country's infrastructure crisis.

2. Research Questions

The research questions for this study are as follows:

- **RQ1:** What is the current state of US infrastructure?
- **RQ2:** What led the US to its current state of infrastructure?

2.1. What is the Current State of US Infrastructure?

According to a recent study by the World Economic Forum, of the 141 nations evaluated using similar criteria, the US currently occupies the 13th position for its current state of infrastructure (World Economic Forum, 2019). The study showed that the US attained full scores in distinct categories evaluated including road networks, electricity provision, and portability of pipe-borne water (World Economic Forum, 2019). Earlier, the United States was placed next only to Singapore in infrastructure ranking using similar ranking criteria (Johnson, 2019).

Given these realities, various American stakeholders have begun voicing concerns about the deteriorating state of US infrastructure (Kiger, 2021). These stakeholders are primarily concerned with the US government's declining investments in infrastructural projects and the lack of efforts to fix deteriorating infrastructures (Johnson, 2019). For example, one stakeholder noted that for every five US bridges, one requires refurbishment. Over 40% of America's roads are in poor or mediocre condition, increasing the number of miles driven on these roads and costing drivers on average $1,000 annually in wasted time and fuel. Roads and highways across the country are essential for moving 72% of the nation's goods with $17 trillion in value. This is partly because there is a backlog of rehabilitation needs since many of the roads were constructed after World War II and are now nearing the end of their useful lives (ASCE, 2021).

2.2. What led the US to its current state of infrastructure?

One major cause of the deteriorating condition of US infrastructure is a lack of adequate funding (McBride and Siripurapu, 2021). Since the public sector typically determines the investments channeled to the nation's infrastructure, and the funds earmarked for infrastructural investment are derived from gasoline taxes, the reluctance of US politicians to raise gasoline taxes for fear of anticipated negative reactions from the electorates will always result in inadequate funds for infrastructural projects (Kiger, 2021).

Another cause of this problem is a lack of incentives among politicians who show reluctance in investing in infrastructural projects, in preference to funding enticing new projects considered appealing to the electorates, whose votes politicians seek in election years (Kiger, 2021). However, most US infrastructures including roads (asphalt) and bridges have outlived their spans of 20–30 years and 50 years respectively (Kiger, 2021). The unnecessary delay in

fixing the public assets, on account of the reasons stated above, despite the continued use of these assets led to their rapid deterioration (Kiger, 2021).

2.3. Factors That Contributed to the Deteriorated State of US Infrastructure

The US infrastructure has been negatively impacted by lack of funding, political polarization, and aging infrastructure, making it difficult to keep up with the demands of the population and economic expansion. Climate change and urbanization have added to the strain on infrastructure, and rural areas have often been neglected. Additionally, insufficient maintenance, overly focusing on road transportation, and a lack of modern technology have contributed to the deterioration of infrastructure. These factors have led to a growing need for increased investment and modernization to ensure the safety and reliability of the country's infrastructure systems.

2.3.1. Rapid Population Growth

The US infrastructure needs to be expanded and maintained as the population of the country keeps rising. According to projections, the population will rise by 60% through migration by the year 2050, reaching 438 million people. This population growth has intensified pressure on public resources like schools and social amenities. This is particularly true for immigrant families, who frequently have more children and are younger than other families.

However, immigrants also have a big impact on the US economy, helping some sectors develop and succeed. They frequently fill positions that may not be appealing to citizens of the country of origin due to their special abilities and qualities. Despite this, the absence of comprehensive immigration reform can result in problems like illegal immigration and the housing of these people, which can further tax the government's resources.

The US's growing population offers possibilities and challenges. It is imperative that the federal government adopt a comprehensive strategy to solve these concerns, one that includes not just infrastructure investment but also the creation of efficient migration policy and immigrant family assistance programs. In this manner, the US may continue to gain from immigrants' contributions while also addressing the problems caused by population expansion.

2.3.2. Rapid Economic Expansion

The relationship between infrastructural development and economic expansion is twofold (McBride and Siripurapu, 2021). While rapid infrastructural development promotes economic growth, accelerated economic expansion necessitates building additional infrastructures to support the economy (McBride and Siripurapu, 2021). As an illustration of this point, a recent study showed that the US loses $120 billion (about $370 per person in the US) on account of traffic congestion on the road (McBride and Siripurapu, 2021). A related study revealed that at least $35 billion (about $110 per person in the US) is lost per year by the US economy due to the incessant delays and trip boycotts attributable to the unsatisfactory condition of the country’s airport system (McBride and Siripurapu, 2021). Another study found that $3 is added to the US GDP for every $1 invested in infrastructural development.[8]

2.4. Depletion of Water Infrastructure

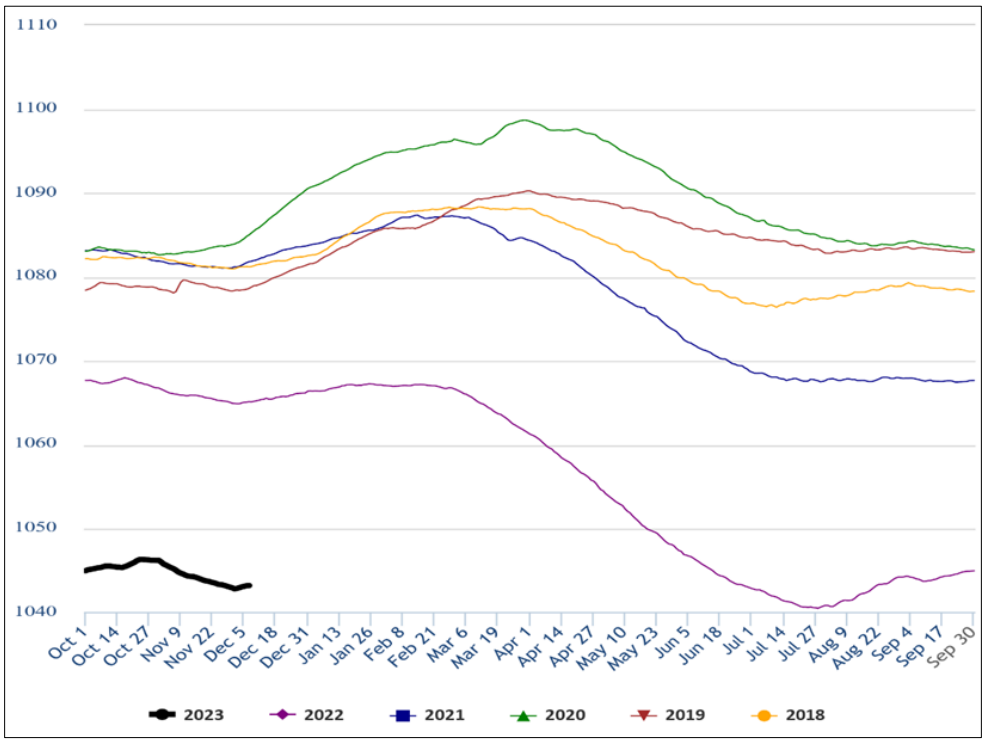
Large firms are using more water to cool their facilities as technology becomes more important, while farmers are using more water for irrigation as the United States works to increase economic production by 2050. These demands have put too much strain on her water infrastructure, making it unsustainable to meet present requirements or prevent the immense issues it would bring about such as drought. The agriculture sector utilizes up to 42% of the US freshwater for irrigation (USDA Economic Research Service, 2022). However, over 15% of the food it creates is wasted, constituting 22% of the garbage dumped in US landfills which are valued at over $161 billion (USDA Economic Research Service, 2014). This necessitates significant investment in culinary infrastructures to help minimize water use in farming by making the best use of food waste. Also, it will lessen the reliance of animal feed producers on fresh farm produce, thereby helping operate hydrothermal plants without overstretching.

People in the city have been forced to use more energy for cooling, which is not sustainable considering drying water bodies like Lake Mead at 22% capacity, Anderson Reservoir at 3% capacity, and Lake Powell at 27% capacity, among other water bodies (water-data.com n.d.). Water bodies are drying as a result of the production of semiconductors, which have the potential to replicate the success of Geneve-Lac-Nation hydrothermal cooling in Switzerland, and they may also have an impact on the Hoover and Glen Canyon Dams, but their energy output is declining. A society's ability to produce energy and have access to clean water can suffer long-term effects from the deterioration of water infrastructure. To produce energy, hydrothermal power plants require a steady flow of water. Communities and people may not have access to reliable and safe water in situations when water supplies are limited or monopolized. As technology develops, it is critical to consider the possible effects of new innovations on water management, including

the use of drones, robotics, virtual reality, telematics, and intelligent transportation systems, which may consume a sizable quantity of water through semiconductors production.

This issue can be resolved by making investments in the maintenance and modernization of existing water infrastructure and by implementing environmental sustainability policies, cutting-edge techniques, and technology designed to maximize water utilization and improve access to clean drinking water.

The government may be able to save other infrastructure and ensure water security by using underutilized water infrastructure. Assessing current infrastructure and making the most of available resources can reduce the need for additional investments and enhance water use. The Great Lakes and Seaway Passage is a complex network of waterways that supports over 227,000 jobs in the US and Canada and over $34 billion in economic activity annually (Byrne, 2022). Despite their potential, the waterways must invest in maintenance and upgrades, protect the environment, and receive funding from the government, businesses, and environmental organizations. By making full use of the Great Lakes and Seaway Passage, the US and Canada could ease the strain on other transportation networks, such as the road and rail systems, and cut back on carbon emissions. Lake Erie, Lake Champlain, and Lake Superior are a few examples of underutilized lakes that could be important for trade and transportation (Great Lakes, 2020). A 1000-foot laker uses 3.5 million gallons of diesel fuel, uses 16.8 million MJ of energy, and emits 46,200 metric tons of CO2. These are significant facts to keep in mind. The trucks use 2,800 vehicles (assumed to weigh 25 tons each), 18.2 million gallons of diesel fuel, which amounts to 87.5 million MJ of energy, and 228,800 metric tons of CO2 emissions, compared to a 1000-foot laker.



Note. Elevation (MSL)

Figure 1 5 Years Water Levels for Lake Mead (2018-2023)

Table 1 Industries, Cities, and Lake Passage

Lake / passage	Roads saved	Industry served/potential	Major cities connected
Lake Erie	I-90, I-79, I-71, I-75	Shipping, tourism, manufacturing, energy, fishing, agriculture, fishing, minerals (iron ore, copper, nickel)	Cleveland, Buffalo, Pittsburgh

Lake Champlain	I-87, I-89, I-91	Shipping, tourism, manufacturing, energy (hydroelectric power), agriculture), fishing, minerals (iron ore, copper, nickel)	Montreal, Boston, Burlington
Lake Superior	I-35, I-53, I-55	Shipping, tourism, manufacturing, energy (hydroelectric power), agriculture), fishing, minerals (iron ore, copper, nickel)	Duluth, Superior, Ashland
Great Lakes and St. Lawrence Seaway Passage	I-90, I-81, I-80, I-70	Shipping	Montreal, Toronto, Cleveland, Buffalo, Chicago, Duluth
Lake Michigan	I-94, I-43, I-41, I-39	Shipping, tourism, manufacturing, energy (hydroelectric power), agriculture), fishing, minerals (iron ore, copper, nickel)	Milwaukee, Chicago, Green Bay
Lake Huron	I-75, I-69	Shipping, tourism, manufacturing, energy (hydroelectric power), agriculture), fishing, minerals (iron ore, copper, nickel)	Saginaw, Bay City, Port Huron

2.4.1. Maintenance Challenges

Because US politicians prioritize projects that attract media hype at the federal level, maintaining dilapidating infrastructure gets less attention from politicians (Olson and Wessel, 2017). The attention of the policymakers is drawn to building new infrastructures than to maintaining the old ones; however, if the question of infrastructural maintenance is raised, its implementation is usually delayed (Olson and Wessel, 2017). In a bid to enforce compliance, the Department of Transportation (DOT) should make efforts (by policymakers) aimed at maintaining old assets (at local and state levels) public (Olson and Wessel, 2017). Unlike infrastructural projects, maintenance projects are apposite for implementation during the downturn, because implementing maintenance projects saves the huge costs associated with infrastructural projects (Olson and Wessel, 2017).

3. Comparing US Infrastructure with Those of Other Nations

3.1. Comparing US Infrastructure with Those of Europe, Canada, and Other Developed Nations

America trails its key allies in Europe and the Middle East in the pace and quality of its infrastructural provision and development (McBride and Siripurapu, 2021). As said before, the World Economic Forum and Global Competitiveness Report placed her in the 13th spot in the overall ranking of infrastructural quality, a drop from the 5th position that she occupied in 2002 (McBride and Siripurapu, 2021). Key allies of the US such as France, Germany, Japan, Spain, the UK, and the U.A.E. overtook the US in the ranking (McBride and Siripurapu, 2021).

For example, Europe's highly efficient train is twice as fast as the current US train (McBride and Siripurapu, 2021). The Business Roundtable ranked only four American airports among the first 50 globally, with the highest-ranked US airport in 30th position. As for internet service, the World Economic Forum places the US in the 18th position for broadband internet service (McBride and Siripurapu, 2021). Despite the US being charged higher than their European counterparts, the internet service that they receive is slower (McBride and Siripurapu, 2021). However, the disparity in the levels of infrastructural quality between America and other developed nations can be attributed to the difference in their levels of funding by the respective governments of other nations (McBride and Siripurapu, 2021).

Table 2 Fastest Countries for Mobile Internet

November 2021			November 2022	
Rank	**Country**	**Median download**	**Country**	**Median download**
1	UNITED ARAB EMIRATE	136.33	QATAR	176.18
2	NORWAY	116.66	UNITED ARAB EMIRATE	139.41
3	SOUTH KOREA	104.97	NORWAY	131.54
4	QATAR	98.10	SOUTH KOREA	118.76
5	CHINA	97.09	DENMARK	113.44
6	NETHERLANDS	94.88	CHINA	109.40
7	SAUDI ARABIA	90.77	NETHERLANDS	109.06
8	CYPRUS	88.79	MACAU (SAR)	106.38
9	BULGARIA	84.59	BULGARIA	103.29
10	KUWAIT	83.63	BRUNEI	102.06

Table 3 Internet Speed Test Global Index Around the World

November 2021			November 2022	
Rank	**Country**	**Median download**	**Country**	**Median download**
1	SINGAPORE	184.65	CHILE	216.46
2	CHILE	173.08	CHINA	214.58
3	THAILAND	171.37	SINGAPORE	214.23
4	HONG KONG (SAR)	153.96	THAILAND	205.63
5	DENMARK	152.31	HONG KONG (SAR)	194.35
6	CHINA	146.62	UNITED STATES	189.48
7	MONACO	141.63	DENMARK	188.35
8	UNITED STATES	134.10	UNITED ARAB EMIRATE	186.76
9	SPAIN	131.46	MONACO	181.26
10	ROMANIA	124.36	ROMANIA	170.25

3.2. Comparing US Infrastructure with China Infrastructure

The Organization for the Economic Cooperation and Development (OECD) revealed that America spends much less on transportation facilities as a fraction of her GDP than most large economies, notably her key European and Asian allies identified in the previous section (McBride and Siripurapu, 2021). The study showed that China spends more than either the US or any of its allies in infrastructural provision (Lew and Roughead, 2021). This trend has been attributed to China's Belt and Road Initiative (BRI), which aims to expand the nation's global economic influence (Lew and Roughead, 2021). The BRI began in 2013 with a view of helping her connect freely with her Asian allies in Southeast, Central, and South Asian regions with a strategic objective of establishing China as a dominant economic power in the region (Lew and Roughead, 2021).

The BRI operated by Chinese banks and industries has funded projects in Asia and beyond the BRI's regional boundaries (Lew and Roughead, 2021). These projects are not limited to the provision of fiber optics cables, telecommunication, highways, and power plants among several others (Lew and Roughead, 2021). The success of BRI is responsible for

China's global economic influence, especially in regions where the US previously wielded more influence than any other nation (Lew and Roughead, 2021).

The US can gain insights from China's infrastructure development and the Belt and Road Initiative. However, it should consider the variations in political systems and governance approaches. China's efficient resource allocation and project execution have bolstered its global economic influence. To benefit from these lessons, the US must adapt them while upholding democratic values, accountability, and transparency. By implementing effective project management and increasing infrastructure investment relative to GDP, the US can improve its infrastructure, remain competitive internationally, and preserve its democratic principles.

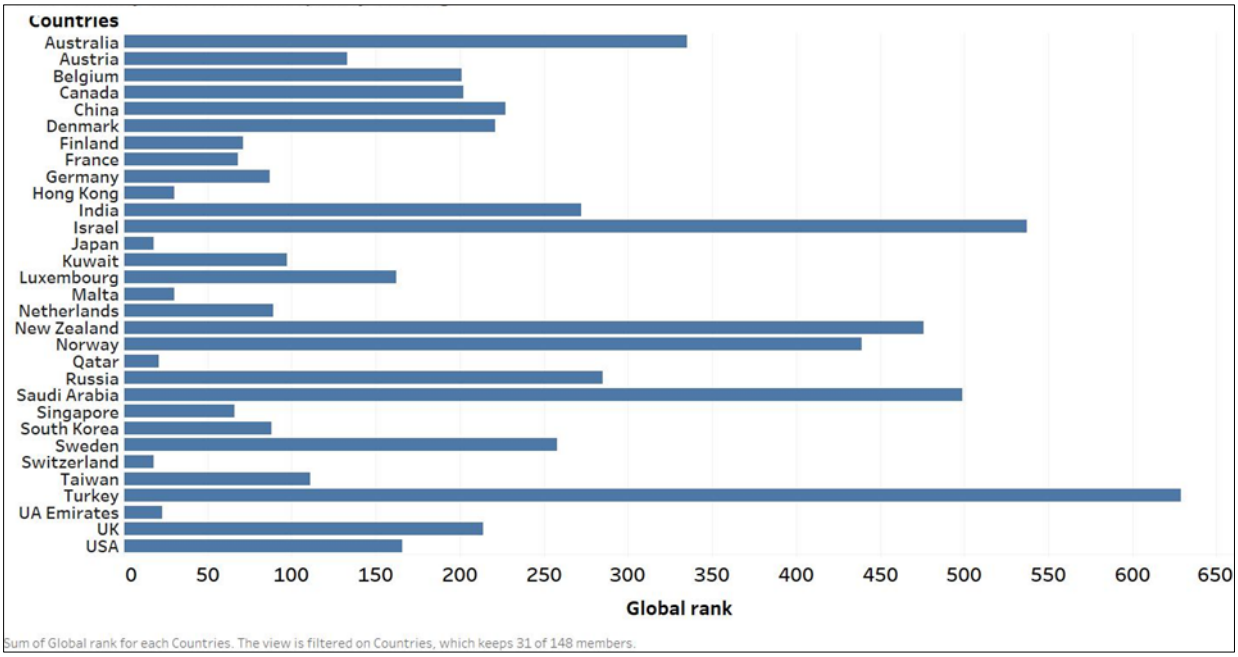


Figure 2 2022 Railway Infrastructure Quality Ranking

3.3. Future Demands of US Infrastructure

The Covid pandemic and the rapid digitization of the global economy (for example, the increase in the adoption of artificial intelligence) brought about new infrastructural challenges: the urgent need to build additional medical infrastructures to meet US health needs and the need to provide sophisticated infrastructures to address the growing digital demands of international businesses within US and beyond (KPMG International, 2022). One major lesson learned from the Covid outbreak is the need to broaden broadband access, as many businesses and organizations operated remotely during the pandemic (KPMG International, 2022). Another major lesson learned during the pandemic was the need to expand the US medical infrastructure to cope with the current pace of population growth (OED, 2021). Finally, the rapid digitalization seen in the emerging economies in Asia and Africa necessitates the demand for tech infrastructure (otherwise known as Infratech) that will enable US tech innovators to leverage the opportunities and challenges that such tech innovations might present in the future (KPMG International, 2022).

4. Conclusion

The poor state of US infrastructures and public assets is a cause for concern for US leaders and stakeholders. The need to address the deteriorating conditions of these assets has generated intense debate among the public and drawn the attention of policymakers. The fact that the US infrastructural provision lags several nations in the annual ranking by the World Economic Forum is a paradox, given that it leads these nations in the global economy. Many stakeholders, opinion leaders, and policymakers have intensified efforts to address the worsening situation of US public assets. To this end, this study focuses on investigating the causes of the current poor condition of US public assets and offers potential solutions.

The study suggests that while President Biden's bipartisan infrastructure plan aims to make significant investments in infrastructure, there is a lack of investment in research and development to update and steer outdated infrastructure

and implement 21st-century techniques that emphasize environmental protection, cost-effectiveness, high performance, and data collection for operation and maintenance. Finally, creating a long-term vision for the country's infrastructure needs and developing a plan to achieve that will help ensure that infrastructure investments align with the country's long-term goals and needs.

Addressing the infrastructure needs of the US by 2045 will require a significant investment of resources and political will and the willingness to think creatively and strategically about how best to allocate resources. By taking a comprehensive and forward-looking approach, the US can build the infrastructure to support a growing population, a thriving economy, and a more sustainable future.

Compliance with ethical standards

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