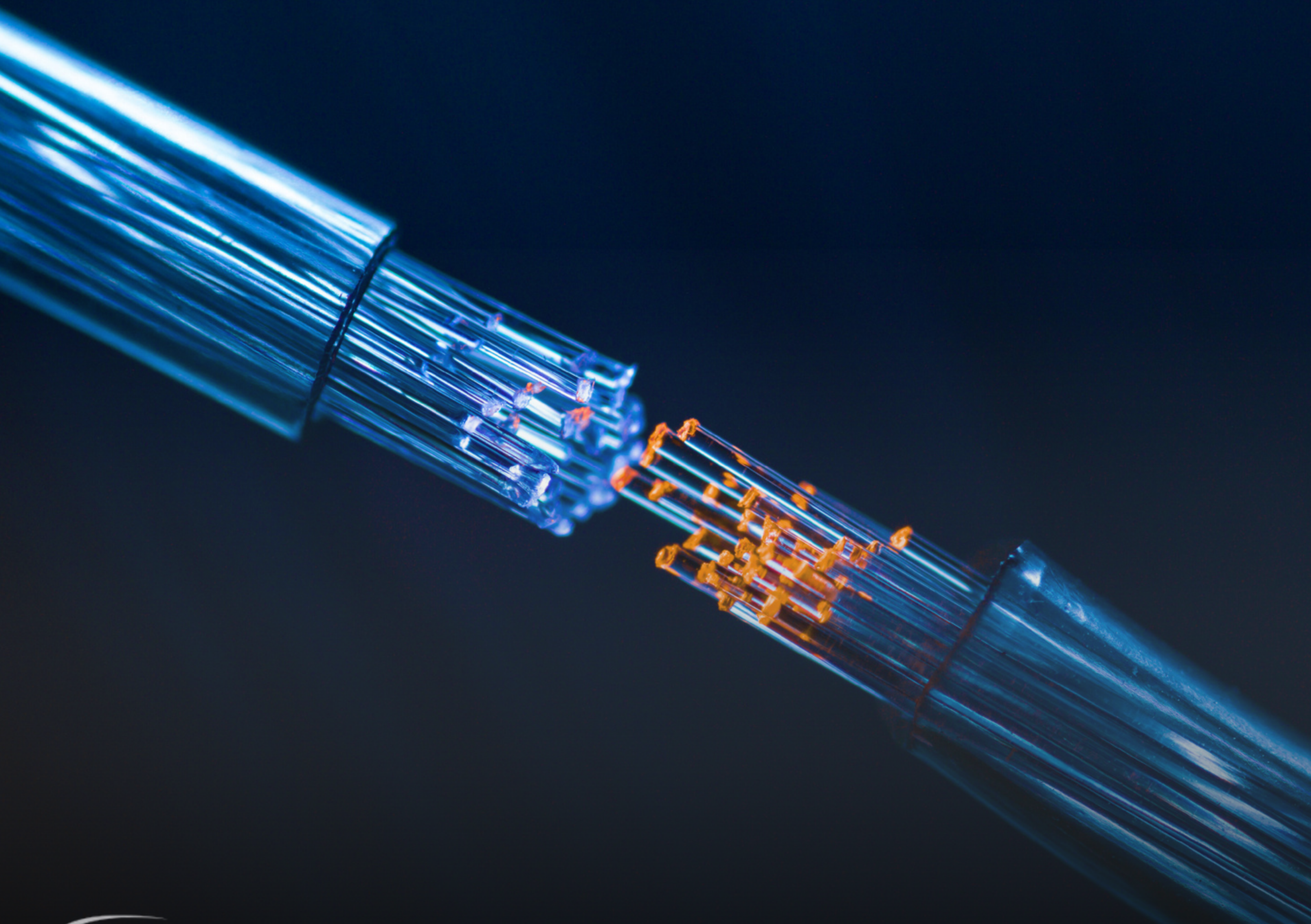
# Broadening Our View on Broadband

Identifying additional benefits from current fiber and future build outs that generate more economic growth and help reduce harm



ALLIANCE FOR INNOVATION AND INFRASTRUCTURE

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## Abstract

There is virtually universal agreement that fiber optic infrastructure is a vital asset and adds value to the economy. Expanded broadband access is routinely linked to economic growth and greater opportunity for individuals, small businesses, and communities; and fiber optic infrastructure is necessary for global internet connectivity. However, there are divisions both within the industry and among policymakers about how far those benefits extend and what true advantages fiber optic infrastructure affords. Even recent academic research has debated these merits, with some projecting highly optimistic economic numbers for increased fiber deployment, while others cast doubt on the extent of projected gains and point to alternative high-speed broadband technologies. As policymakers consider existing telecommunications infrastructure and alternative technologies, it is critical to understand the full range of potential that assets can achieve.

Where fiber is concerned, there are numerous critical applications that should be evaluated more thoroughly. Limiting the role of fiber to data transmission underestimates its capacity to deliver concurrent and transformative benefits. Innovative uses of fiber technology enable multi-use applications that extend across numerous industries and vertical markets into a single solution. Such cross-sectoral engagement produces new synergies to add value, resolve pain points, and make infrastructure safer, more efficient, and more resilient. Likewise, fiber optic infrastructure enables other solutions by serving as a foundational platform upon which innovators and public entities can build novel technologies, services, and applications – many of which may be unforeseen at the time of installation but emerge to meet evolving needs and unlock new value across sectors.

When factoring these considerations into the analysis, increased deployment of fiber optic infrastructure has not only greater economic value than many realize, but certain applications even have the potential to reduce harm and provide real-time intelligence for public and private sector needs.

## Introduction

The U.S. broadband network spans millions of miles of copper, cable, and fiber connections, forming the backbone of modern communications and digital connectivity. Investment in faster and more accessible telecommunications infrastructure has created trillions of dollars in Gross Domestic Product (GDP).[1] The latest Infrastructure Report Card from the American Society of Civil Engineers (ASCE) included broadband as a core chapter for the first time in 2025, recognizing its vital importance to the economy and population.[2] Not only was it a newly included category of infrastructure, but it scored among the highest of any infrastructure component nationwide. This recognition aligns with the federal government designation of "Communications" as one of the 16 critical infrastructure sectors, highlighting its foundational role in modern society.[3]

Despite advances in broadband – and communications infrastructure as a whole – substantial challenges remain to ensure accessibility to reliable and fast connections for all Americans. As data generation accelerates at an unprecedented pace, the need for low-latency, high-bandwidth internet and wireless services grows in parallel. This demand will only intensify as emerging Artificial Intelligence (AI) technologies reveal their far-reaching implications.

The 2025 ASCE report card stressed that significant investments need to continue in order to provide services to millions of Americans still without a high-speed connection, and that innovation and security will need to improve to lower costs and maintain safety.[4] With the stakes rising, it is increasingly urgent that new investments not only expand access, but also prioritize scalable, future-ready infrastructure capable of supporting a range of technologies. Ensuring these investments are prudently targeted is both a public and private priority – and a necessary foundation for broader federal policy decisions ahead.

The federal Broadband Equity, Access, and Deployment (BEAD) initiative was designed to help connect all Americans to high-speed internet. The $42 billion program has been highly anticipated by the states, industry leaders, and lawmakers.[5] Although established in 2021, the program has yet to leave the planning stage, and has been through a long mapping and coordination process with the states. Connecting more people to symmetrical (both fast downloads and uploads), low-latency high-speed internet has repeatedly been shown to improve economic outcomes and open business opportunities.[6]

However, the new administration has signaled that it is not happy with the direction of BEAD, and will be "revamping" the program to "take a tech-neutral approach."[7] This revamp has generated concern from state and local lawmakers about further delays from a program that has still not confirmed funding for any projects in more than three years.[8] Although officially focused on results over method, BEAD was noted by some to designate fiber as preferred technology, followed by fixed wireless (FWA) and alternative technology like Low Earth Orbit

(LEO) satellite internet or unlicensed wireless as a lowest priority option.[9] The BEAD program and the new administration's "readjustment" is one of the primary reasons for renewed discussions around fiber internet, high-speed broadband, and new economic evaluations.

In light of this discussion, it is important to examine the technologies used in broadband deployment, with a focus on the broader potential of fiber optics. Fiber optic technology, which delivers significantly faster speeds than traditional telecommunications cables, has become a cornerstone in global connectivity and data corridors.[10] While consumers have various options for internet service, nearly all internet infrastructure is connected by fiber; it is only the last-mile or final stretch that a connection may be switched to copper cables, LEO, or wireless. Today, around half of all U.S. households have a direct fiber internet connection, a share that has been growing significantly in recent years.[11]

In addition, the United States significantly lags the Organization for Economic Co-operation and Development (OECD) average in fiber subscriptions as a percentage of fixed broadband service, a reality that could potentially undermine current and future economic competitiveness.[12]

As interest in fiber and high-speed broadband alternatives rise, it is essential to consider not only the technology's role in telecommunications, but also the wider implications of its deployment. Fiber is capable of much more than just providing high-speed broadband. To fully realize the benefits of future installations, policymakers and stakeholders must recognize fiber as more than a piece of critical infrastructure, but also an enabler of future growth and additive opportunities.

## Ranging Economic Evaluations

There is little doubt that broadband access is closely related to economic growth and opportunity. The gap between highly connected areas and those with limited service, known as the *Digital Divide*, reflects the strong link between internet connectivity, wealth, and economic success.[13] While the digital divide often affects poorer Americans, it is most pronounced between rural and urban areas. In rural America, more than 14 percent of households lack access to a broadband connection, compared to just three percent of urban households.[14] This digital divide has been studied extensively by researchers, and often forms the basis of measuring the impact of broadband and fiber optics on the population at large.

A 2021 study found that broadband availability is strongly correlated with jobs and GDP growth, and that a 10 percent increase in broadband penetration nationwide in 2016 would have resulted in more than 806,000 additional jobs by 2019.[15] Improvements to broadband speeds drive noticeable improvements in job growth, though with diminishing returns.[16] In the EU, broadband and fiber also had a major impact on GDP.[17] In other words, the relationship between high-speed broadband and economic growth is well established. Connectivity is more crucial than ever to success.

Beyond economics, studies routinely link broader quality of life issues to broadband access. One recent example includes a KFF Health News story in March 2025 exploring how poor internet access leads to worse health outcomes, with particular emphasis on those suffering from diabetes in rural areas.[18] Still, broadband delivery methods vary, requiring analysis of individual options.

There have been several large studies on the economic impact of fiber itself. Increased fiber deployment is associated with economic productivity and innovation.[19] A 2022 study found that increased fiber adoption and faster internet added $1.3 trillion to the U.S. GDP between 2010 and 2020.[20] Case studies have demonstrated that fiber deployment is associated with increased home value, employment, and economic activity at a local level.[21] Between 2010 and 2020, fiber deployment added over $2.5 billion to a local Tennessee economy, directly helping create thousands of jobs and having an estimated value-to-cost ratio of 4.42.[22]

In November 2024, the Brattle Group released a report commissioned by the Fiber Broadband Association and Frontier Communications showing a substantial link between fiber deployment and increased home prices, incomes, and employment. The report claimed that "...deploying fiber to the 56 million households that are in tracts unserved by fiber, has the potential to generate at least $3.24 trillion in terms of net present value (NPV) in incremental economic impact."[23] About half of this added value was in the form of increased housing equity, while the rest was in increases in income for unserved households. Brattle also estimated that deploying fiber to the 77 million Americans in the workforce without high-speed internet has the potential to create at least 380,000 new jobs by giving potential workers access to work-from-home jobs. Although not included in economic estimates, Brattle argues that increased fiber deployment will improve healthcare outcomes, including increased use of telehealth and remote operations in areas underserved by healthcare providers.

In March 2025, the Phoenix Center for Advanced Legal and Economic Public Policy Studies responded to the Brattle paper, criticizing the economic model and claiming that it overestimated the economic impact of fiber.[24] The Phoenix bulletin argues that the Brattle study is flawed, failed to test core assumptions like parallel trends, and used questionable definitions of urban and rural areas. Upon reanalyzing the same data, the Phoenix Center contends there is no significant evidence that fiber specifically leads to meaningful economic improvements in home value, income, or employment. Phoenix subsequently challenged findings in the KFF article that tied improved broadband access to healthcare outcomes.[25] The critique is not that broadband does not provide meaningful benefits, but its effect on health outcomes is not statistically significant amid so many other factors and conditions.

These papers take place in the backdrop of the BEAD program's reevaluation. If the Department of Commerce significantly alters the program, it could shift prioritization or funding away from many potential fiber projects toward alternatives like LEO internet and other technologies.

Stakeholders are trying to prove that their technology is effective and economically sound, leading to conflicting opinions and studies. These debates over federal programs and economic studies have primarily focused on fiber's role in delivering broadband access. Yet, this narrow framing may miss critical economic value from the larger picture. While the studies investigated economic impact by measuring housing value, income levels, and employment as it relates to fiber broadband access, each of them missed out on the numerous applications provided by deploying critical fiber broadband infrastructure.

The primary purpose of fiber optic infrastructure is to provide internet and data services, but fiber then becomes a springboard for additional infrastructure synergies and new opportunity. Finally, an often-overlooked multi-use functionality of fiber is distributed fiber optic sensing, which can add further value to the economic case for increased deployment, both producing new value and reducing common costs.

## Fiber-Enabled Opportunities

Building up from the well-understood link between broadband connectivity and economic advancements, there are at least five key infrastructure opportunities enabled by fiber optic infrastructure that is inadequately captured in many analyses. These include Smart Grid Modernization, Mobile Wireless Networks, Quantum Networking, AI, and Distributed Fiber Optic Sensing. Individually, these set fiber optic infrastructure uniquely apart from alternative technologies, and together form the basis for a future of smarter cities and interconnected infrastructure that generates new and unlockable economic opportunity.

### *Smart Grid Modernization*

Fiber optics enhance smart grid modernization and integration by providing the high-speed, high-capacity backbone for communication. A Smart Grid is an advanced electricity distribution system that uses digital technology and real-time communication to manage energy supply and demand efficiently. Fiber optics, as the cornerstone of global communication networks, provides increased reliability, data transmission, and security compared to traditional copper telecommunications cables. Other potential solutions, such as fixed wireless and LEO internet, are vulnerable to weather disruptions, making them significantly less reliable for power grid solutions.

By design, smart grids use advanced two-way communication technologies, control systems, and advanced computer processing to function.[26] As the most developed technology for high-speed data transmission, using fiber optics to control these connections is the most logical step forward. A study from the Pacific Northwest National Laboratory found that implementing smart grids across the United States would lower utility bills by more than 10 percent, and result in up to $50 billion annual net savings.[27] Smart grids could reduce peak electricity loads by nine to 15 percent and decrease the wholesale cost of electricity by seven to 14 percent.[28]

Implementing a smart grid will require major investments to modernize existing energy transmission and distribution systems, but these upgrades can reduce the need for building new energy infrastructure. At a time when energy transmission development cannot keep up with demand, improving efficiency with smart grids is critical.[29]

Fiber optic cables also enhance security, as they are far less susceptible to electromagnetic interference than copper cables. Multiple government agencies have recognized the energy grid as one of the most important systems to keep safe from physical and cyber threats.[30,31] With fiber optics, utilities can continuously monitor and manage grid operations, collect and analyze vast amounts of data, and quickly respond to fluctuations in demand or faults in the system.

***Mobile Wireless Networks***

Fiber optics are foundational in modern mobile wireless networks by making the connection between cell towers and the broader internet. While mobile devices connect wirelessly to cell towers, data from those sites ultimately comes from physical data centers, server connections, and data highways made of fiber optic cables. Fiber optic cables enable this connection with low-latency and high-bandwidth, making wireless networks faster and more reliable.

As mobile networks expand to ever-more remote locations and handle increased data-heavy communications, fiber connections to these locations will be necessary. Unlike other telecommunication options, fiber's high-bandwidth capacity ensures it can scale to meet future demands without the need for upgrades or network overhauls. 5G, which is rapidly expanding across the U.S., relies on fiber optic cables for ultra high-speed connections.[32]

Put simply, fiber is not just required for home or business internet connections, but also wireless cell connections we use every day. Data traffic from wireless networks is increasing rapidly. In 2014, Americans used 4.1 trillion megabytes of data from mobile wireless networks.[33] In 2023, it was 100.1 trillion megabytes.[34] This level of growth isn't possible without fiber, which remains the most efficient way to move the huge amounts of data Americans use every day.

***Quantum Networking***

Fiber optic communications are necessary to the development of quantum networking. Quantum networks are communication systems that use the rules of quantum physics to send information in a way that is much more secure than today's internet.[35] Instead of using regular bits like 0s and 1s, quantum networks use quantum bits, called qubits. Qubits can do complicated things, like be in multiple states at once or instantly affect each other even when far apart. Quantum networks are on the cutting edge of technological development, with research teams and governments working on its development around the world.[36] A majority of industry professionals believe that quantum computing technology will be superior to classical computing in less than 10 years.[37]

Despite sounding almost like science fiction, quantum networks are expected to utilize existing fiber optic cables to transmit data.[38] In quantum computers, entangled photons are used that carry special information. Traditional light signals in fiber optics can be amplified and copied easily, but entangled photons are "fragile" and must be handled carefully.[39] Researchers have demonstrated that fiber optic cables have the range and bandwidth to transmit entangled photons alongside classical signals.[40] For ultra long distances, quantum repeaters will be needed, but fiber represents the best solution for quantum communications.

Quantum computing and networking represent the next generation of information technology, set to define a new era of technological process. The same fiber optic cables that power the internet today will serve as the anchor of the quantum future.

***Artificial Intelligence***

As the digital world continues to expand, the demands on data centers grow exponentially. At the heart of this growth is AI. This technology relies on hardware and software that can perform tasks typically requiring human intelligence.[41] AI can recognize images, process language, and make decisions. Creating an *intelligent* machine involves training it with vast datasets and powerful computing software.

Fiber optics play a vital role in supporting the growth of AI by enabling the high-speed data transmission these systems require. As AI models become more advanced and are deployed across dozens of industries, the volume of data collected, processed, and stored will increase exponentially. Fiber networks are currently the only option that has bandwidth capacity necessary to allow this data to be moved quickly and reliably between data centers, cloud platforms, and user devices.[42] LEO and fixed wireless internet can deliver high-speed access to homes and businesses, but they lack the capacity for large-scale data transmission needed to interconnect data centers around the world.

AI's need for increased data capacity could result in many of the installed but unused (or *dark*) fibers already present in a cable being utilized for the first time.[43] Because fiber optic cables contain up to hundreds of individual fibers, there is often greater capacity and potential than is being used at any given time. Without the capacity and speed from fiber optic cables, data transmission could face bottlenecks that limit their potential.

***Distributed Fiber Optic Sensing***

Fiber optic sensing is perhaps the least-known, largest economic opportunity that comes from fiber other than telecommunication applications. Fiber optic sensors are used in everything from science experiments to perimeter security. Regular fiber optics transfer signals by sending light pulses through long cables of silica, or glass, without the need for electrical signals, transmitting data quickly and efficiently. Fiber optic sensing works a little differently.

Instead of sending data as light signals, fiber optic sensors measure the minute imperfections in backscattered light within the fiber to measure things like vibration, temperature, strain, and pressure. By precisely measuring how light changes as it moves through a fiber, the entire cable can act as a sensor, and conditions can be measured and pinpointed anywhere across the entire length of the fiber.

For example, a fiber optic sensor deployed along a pipeline could not only detect a leak nearly instantaneously by measuring the change in temperature, pressure, or acoustic signals, but it can accurately pinpoint the location of the leak for quick response.[44] Fiber optic sensors can continuously collect data across many miles of cable without the need for electricity or other infrastructure, other than a small box of hardware called an interrogator.[45]

Distributed Fiber Optic Sensing (DFOS) can leverage this capability by utilizing existing fiber optic infrastructure to monitor the local environment. The individual fibers within a can each carry many terabytes of data per second.[46] Without impacting existing services or use of other fibers, *dark* fiber optic strands can be converted into distributed fiber optic sensors. The technology only requires the use of one fiber optic strand not currently carrying data transmission.[47] In effect, all the above-detailed applications of fiber optic infrastructure can be utilized concurrently with DFOS.

Because fiber optic cables are often already buried alongside infrastructure corridors, the sensor can be used to improve the resilience of a host of existing utilities and transportation systems. DFOS use cases include[48] but are not limited to:

***Pipeline Monitoring and Leak Detection***
Fiber optic sensing has long been used in pipelines to detect leaks and abnormalities, preventing larger spills and finding leaks on multiple occasions.[49]

***Utility and Excavation Damage Prevention***
DFOS can be used to protect underground utilities located on infrastructure corridors alongside fiber optics by notifying utility operators of unexpected ground disturbances.

***Border Security***
Fiber Optic Sensing provides a powerful solution for border or perimeter security by identifying and classifying vibrations caused by footsteps, vehicles, tunneling, or digging.

***Structural Health Monitoring***
Fiber optic lines along infrastructure corridors can be used to measure the structural health of bridges and other infrastructure, enabling proactive maintenance.[50]

***Telecom Network Monitoring***
One of the easiest ways to utilize DFOS is in monitoring the telecommunications network, which can improve maintenance schedules and save costs.

***Traffic Monitoring***
DFOS already enables real-time traffic monitoring by detecting and classifying vehicle movements through vibration patterns along roadside fiber optic cables. The sensing capabilities of fiber networks deployed adjacent to roadways may even serve as an enabler for future autonomous vehicle networks.

***Manhole and Utility Intrusion Detection***
DFOS can be used to detect unauthorized access to manholes and other restricted areas. This can be useful for utilities and local governments in order to prevent security threats.

***Earthquake and Geologic Sensing***
Distributed fiber optic sensors can be used for earthquake measurement, helping pinpoint the origin for earthquakes and trigger early warning systems for both earthquakes and resulting tsunamis that can save lives.[51] This utility has been discussed by geologists for use in seismology research.[52] Monitoring for tremors also has potential application to oil and gas extraction and underground mining.[53]

As software advances continue to expand DFOS applications, policymakers and industry leaders should treat its multi-use potential as a strategic factor in fiber deployment. Taken together, these opportunities position fiber not merely as a broadband technology, but as foundational infrastructure for the next generation of economic, technological, and societal advancement.

## Limitations and Alternatives

Fiber optics are essential for the future of information technology, energy systems, telecommunications and more, but the technology is not without limitations. Fiber is already heavily deployed across population centers, with more than 64 percent of urban areas covered by fiber, compared to 37 percent of rural ones.[54] This means that future fiber deployment will be slightly more focused on rural areas, which may increase deployment costs. Multi-use capabilities may reduce these costs or lower peripheral regional costs to make deployment more feasible. In areas where deployment is strong, the need for new fiber will be secondary to activating existing capacity from unused dark fibers.

Digital connections to data-hubs and high-capacity data corridors will still require fiber infrastructure, but broadband connections to individual homes and businesses can be served by other methods. Solutions like FWA and LEO satellite internet can connect low-density, rural communities where building fiber optic infrastructure is cost prohibitive, such as remote areas with tricky terrain. Fiber deployment often has to contend with right-of-way and permitting issues, challenges not present in wireless internet.[55]

Fiber, FWA, and LEO internet have all been increasing significantly in market share since 2021.[56] A robust digital future will require continued innovation across all platforms, with a balanced strategy that embraces innovative new methods while also advancing the deployment of fiber optics-based critical broadband infrastructure. Policymakers and industry leaders will need to carefully assess where new fiber deployment is most economically and functionally justified, while remaining open to innovative alternatives.

## Policy Considerations and Recommendations

As policymakers look to maximize the value of broadband infrastructure investments, it is essential to broaden the scope of how economic value is determined. The increasing dependence on digital networks and the amount of data transmitted each day underscores the need for reliant and resilient infrastructure. Current economic models and studies examining broadband have undervalued the enabling and springboard effect of fiber for future opportunities and even anticipated demands on our infrastructure. Likewise, a great body of research seems not to be aware of the multi-use and real-time monitoring capabilities of fiber optics as continuous sensors. Validating quantitative research is called for – to evaluate fiber optic infrastructure for the many capabilities that only fiber can provide even concurrently with its broadband services – which industry leaders and policymakers must consider.

The BEAD program is currently under review by the new administration. As policymakers reconsider the approach of the program, it is crucial to consider all of the variables. Fiber has been criticized for not always being the most cost-effective approach in rural areas, but enabling and additive opportunities like smart grid modernization, mobile wireless networks, quantum networking, AI, and DFOS add significant economic value – and contribute to cost reduction – that is not typically measured in existing research and literature. Policymakers must recognize and account for these and multi-use benefits when evaluating funding criteria and future impacts.

Congress should also consider fiber's applications to other programs and industries due to these multi-use benefits. There are other federal programs that consider broadband deployment and fiber optics. The Enabling Middle Mile Broadband Infrastructure Program was a separate program created in the Infrastructure Investment and Jobs Act that awarded almost $1 billion in grants for fiber deployments.[57] Notably, the program was oversubscribed, with applications totaling $7.47 billion in requested funding, signaling high demand for fiber deployment across the nation.[58] As Congress refines surface transportation reauthorization, policymakers should consider integrating policies that encourage coordination between transportation and broadband infrastructure investments, as well as new programs that encourage fiber deployment.

Equally important to policy action is the investment from stakeholders and private business. Fiber optic infrastructure is forecasted for significant growth over the coming years, driven by demand for faster internet, AI, and fiber optic sensing.[59] The multi-use and cross-sector benefits of fiber optics can be utilized by many businesses through coordination and development. Sustained investment into fiber infrastructure is crucial for ensuring fiber remains a high-density and high-capacity solution.

There is a clear need for quantitative research to better measure the broader economic value fiber and DFOS can provide. Independent researchers must develop models that accurately capture the future growth and innovative value from increased fiber deployment. Without broadening the economic lens beyond consumer internet access, the true value of fiber may be underestimated. Innovation is critical in both reducing the digital divide and providing other avenues for advancement. DFOS is an excellent example of innovating existing technology to improve efficiencies across sectors. Other innovative solutions for broadband, including LEO satellite internet and fixed-wireless access should also be encouraged.

## Conclusion

Fiber optic infrastructure has already been proven as a critical driver of economic growth and connectivity, but its full potential remains underappreciated and unquantified. As technology evolves and digital infrastructure demands grow, it is essential for policymakers and industry leaders to recognize fiber optics' broad multi-use applications. Fiber applications like Smart Grid Modernization, Mobile Wireless Networks, Quantum Networking, Artificial Intelligence, and Distributed Fiber Optic Sensing deliver substantial public benefits and generate significant economic value.

Expanding research efforts to quantify these extended benefits will be necessary to ensure public and private initiatives make the best possible decisions for future investment. As an independent, cross-sector think tank with a track record of infrastructure research, the Alliance for Innovation and Infrastructure (Aii) is uniquely positioned to lead this essential inquiry and help guide policy and investment decisions with objective, data-driven insights. By broadening our perspective, we can unlock new opportunities for innovation, economic growth, and public good for decades to come.

To meet this moment, policymakers and private stakeholders must align strategically to deploy and activate fiber infrastructure with intention. Failure to do so risks falling behind global peers in technological readiness, economic competitiveness, and infrastructure resilience. Integrating fiber into broader strategic plans – from transportation to energy to national security – will be essential in realizing its full, transformative potential.

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