Fiber Deployment Cost Annual Report

2023

Fiber Broadband ASSOCIATION

Cartesian®

When fiber leads, the future follows.

EXECUTIVE SUMMARY

The Fiber Broadband Association partnered with Cartesian to research the cost of fiber deployment and provide insight on how costs are evolving over time.

Cartesian received input to this study from across the industry and nation. Respondents spanned the fiber construction ecosystem from traditional providers to contractors and represent 35 states in total based on primary deployment locations. Information was gathered via phone interviews and online survey in October and November 2023.

While no two deployment projects are alike, we found many common themes.

The cost per foot of aerial deployment is less than half that of underground

Typical costs ranged from $11 to $24 per foot for underground deployment, and $4 to $9 per foot for aerial deployment. The median cost of deploying fiber underground was over twice the median cost of deploying fiber aerially at $16.25 and $6.49 respectively.

Labor accounts for over two-thirds of build costs

These costs were largely driven by labor, which comprised 50 – 90% of total cost, leaving materials to contribute 10% - 50%. The average split was 73% labor, 27% materials for underground construction, and 67% labor, 33% materials for aerial construction.

Population density has a large impact on the cost per foot of underground builds

Costs also related to population density; median costs increased with density. Extremely rural areas reported the lowest median underground cost ($12.50/ft), while urban areas reported the highest median ($23.25/ft), almost double that of the most rural scenarios. This generally held true for aerial deployments also, with a median of $5.00/ft for rural and $6.54/ft for urban areas.

Building in rocky areas costs twice as much as laying fiber in soft earth

Underground costs are also influenced by terrain; the denser and harder a terrain is, the more costly it becomes to dig under the surface. This was evidenced in the results, as underground deployment had a median cost of $10/ft in soft earth, but twice that in rocky terrain at $20/ft.

Where available, a choice of construction method can reduce cost

There are a variety of construction methods for underground build, each occupying its own niche. Trenching had the lowest reported median cost at $12/ft and plowing the highest median cost at $17/ft. Directional boring fell in the middle at a median of $15.10/ft, but also had the highest reported costs of any method.

The Western states had the highest cost ranges

Deployment costs varied by region for both aerial and underground methods, although regional differences tended to be more pronounced for underground construction. For both methods, the West had the highest typical costs, and the Northeast had the lowest typical costs.

Anticipated cost increases expected to cool slightly

While 46% of respondents reported “significant” cost increases in 2023 (greater than 10%), only 24% expect the same in 2024. Most respondents (59%) predict a slight price increase (less than 10%) and 13% expect costs to remain the same.

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INTRODUCTION

The US is in the midst of one of the largest infrastructure programs ever undertaken. Broadband providers are replacing legacy networks with fiber and reaching new communities through footprint expansion. Over half of US households now have access to fiber broadband and providers have committed to delivering millions more fiber homes in the coming years.

Alongside this commercial activity, federal and state funding programs are helping to extend the reach of fiber deployment. The largest of these – the Broadband, Equity, Access, and Deployment (BEAD) Program – provides $42.45B to deliver reliable, high-speed broadband to every American.

With national focus on closing the digital divide and billions of federal dollars being directed towards fiber deployment, understanding the cost of building networks is critical now more than ever. Understanding deployment costs will help efficiently direct BEAD dollars and other funding sources to connect the communities most in need. However, until now, the industry has lacked a dedicated resource to assessing how costs vary in different environments and change over time.

Recognizing this research gap, the Fiber Broadband Association (FBA), in partnership with Cartesian, set out to understand the range of costs facing providers today and how these are expected to change. This study provides the industry with a comprehensive assessment on the state of fiber in the US. In doing so, we focus on the cost of deployment, which has long dictated where and when broadband infrastructure is built.

In this report, we summarize the fiber deployment landscape in 2023, present findings from our annual fiber deployment study, and look ahead to 2024 for developments in the industry.

Section 1 looks at this past year for fiber deployment through deployment numbers, trends, industry news, and BEAD updates.

Section 2 provides an overview of the factors that impact fiber deployment costs and details findings from this year's Fiber Deployment Cost Study.

Section 3 reviews cost trends based on findings from the Fiber Deployment Cost Study and summarizes expectations for the coming year.

SECTION 1: FIBER YEAR IN REVIEW

46% of locations in the US now serviceable by fiber

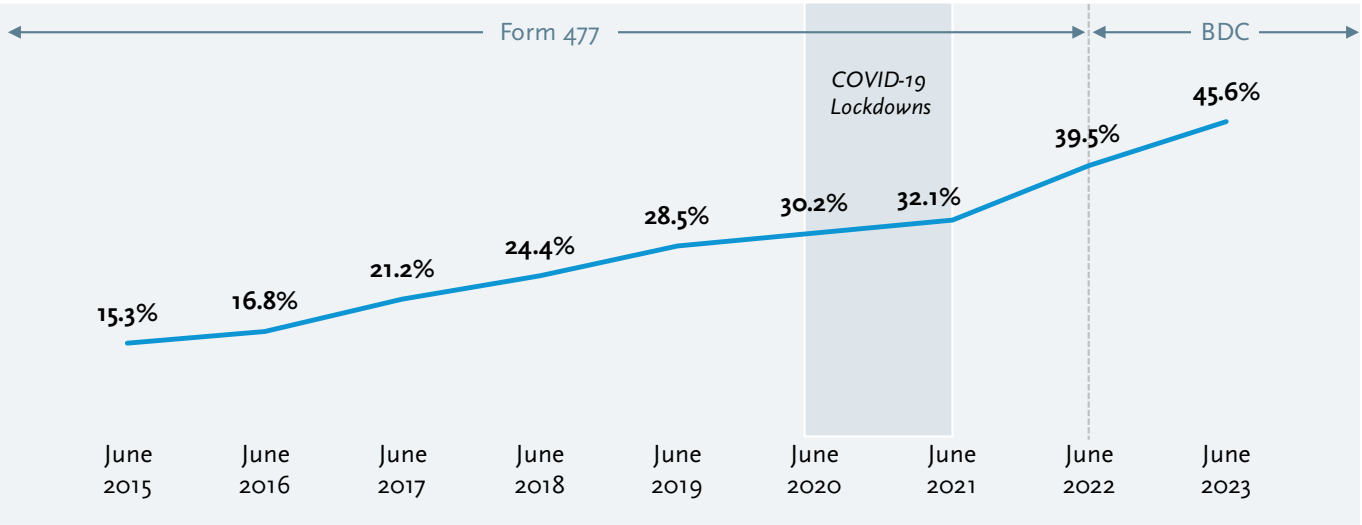
Fiber deployment had another record year in 2023. According to the FCC's Broadband Data Map, we estimate that roughly 52M or 46% of locations in the US are now serviceable by fiber as of June 2023. This includes 7.6M additional locations from last June, a 6-percentage point (pp) YoY increase in coverage.

Providers are now expanding fiber to new locations faster than ever, as evidenced by the notable uptick in deployments since 2021. This comes after a temporary slowdown starting around 2020, in large part due to COVID-related disruptions.

Fig 1.1

Fiber Access in the US by Share of Locations (2015 – 2023)

% of Locations Serviceable by Fiber



Source: FCC Form 477 and Broadband Data Collection (BDC) filings, accessed 11/2023

At a household level, the figures are even more impressive. According to RVA LLC's recent study, fiber passed 69M unique homes as of Q3 2023, equivalent to 51.5% of US households[1]. The FCC's location data lags this household view as it doesn't reflect the full contribution of multi-dwelling units (MDUs) to the total amount[2].

Fiber deployment keeps momentum this year

Fiber deployment in 2023 kept pace with the record-setting levels of 2022; households passed increased by 13% in 2023, which mirrors YoY growth from 2021 - 2022[3]. The 2023 deployment figures even beat earlier expectations, despite some national providers slowing down their deployments in response to economic headwinds.

Although high inflation and interest rates may have dampened the outlook early in 2023, it did not deter deployment on a broad scale. Thanks in part to excess materials inventory acquired during the COVID-19 pandemic, many larger providers were shielded from some price fluctuations.

[1] Fiber Broadband Association, RVA
[2] The FCC Broadband Data Map treats each MDU – many of which are served by fiber – as a single location.
[3] Fiber Broadband Association, RVA

2023 also showed that providers aren't waiting for BEAD money to expand their networks. Private capital is continuing to invest in fiber, which is viewed as an "infrastructure class" investment. There's also plenty of other government funding currently accessible, including the American Rescue Plan Act's (ARPA) Capital Projects Fund and Rural Digital Opportunity Fund (RDOF). ARPA dollars must be obligated by the end of this year, and many states are keen on getting those funds out the door before BEAD.

More consumers are seeing increased options when it comes to fiber

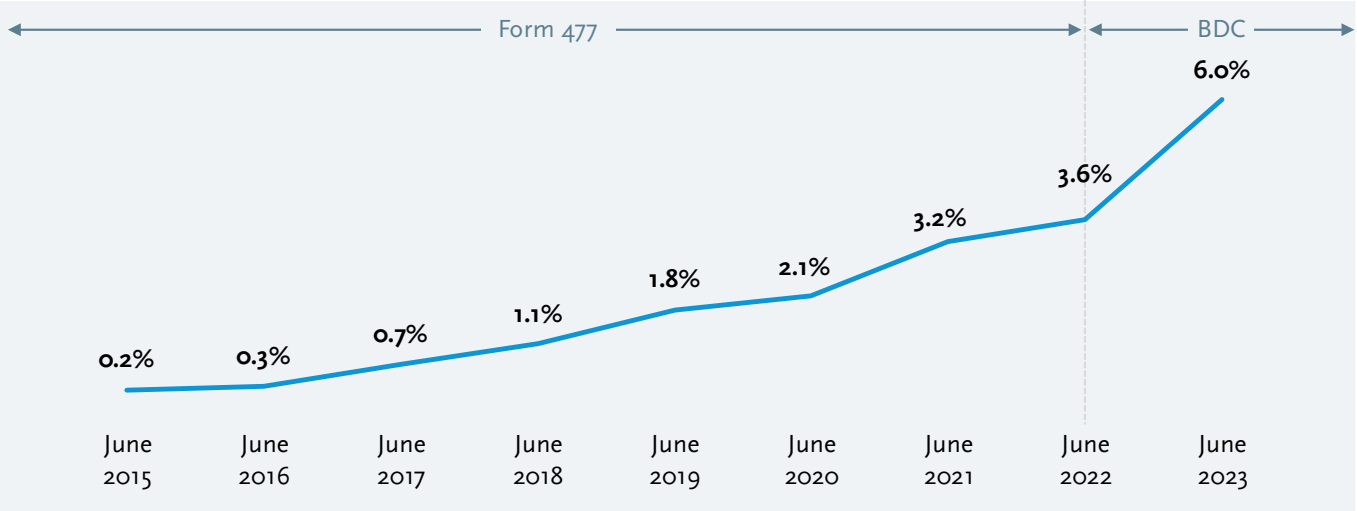
The number of locations in the US with access to multiple fiber providers has tripled in recent years, at a rate faster than overall access. As of June 2023, 6% of locations are passed by at least two fiber providers. In contrast, until recently fiber deployments rarely overlapped; in 2020, the percentage of locations with more than one fiber option stood at 2.1%.

The increased fiber competition is likely due to two causes: overbuilder entrants and legacy network upgrades. Both models signal fiber's long-term viability: overbuilders are finding it lucrative to take on incumbents in some markets and legacy providers are likely deploying fiber to remain competitive in their footprints.

Fig 1.2

Fiber Access in the US by Share of Locations with 2+ Providers (2015 – 2023)

% of Locations Serviceable by 2+ Fiber Providers



Source: FCC Form 477 and Broadband Data Collection (BDC) filings, accessed 11/2023

Everyone is getting in on fiber

We didn't get to where we are today—over half of US households serviceable by fiber— without collective efforts across the broadband industry to build fiber.

While ILECs led the way in the early years of deploying fiber, broadband providers of all types are now getting in on the action. In recent years we've seen diversification in the types of companies building fiber, including cable operators, municipalities, and electric cooperatives in addition to traditional telcos. This is in part due to increased capital, as mentioned above, and in response to growing consumer demand for faster and more reliable speeds.

Subscriber challenges and heightened competition have led some cable operators to start building fiber. It's increasingly common for cable companies to upgrade their HFC networks with fiber and to deliver FTTH in greenfield areas. As cable companies see revenue and/or subscriber success with fiber, we can expect the fiber trend to continue.

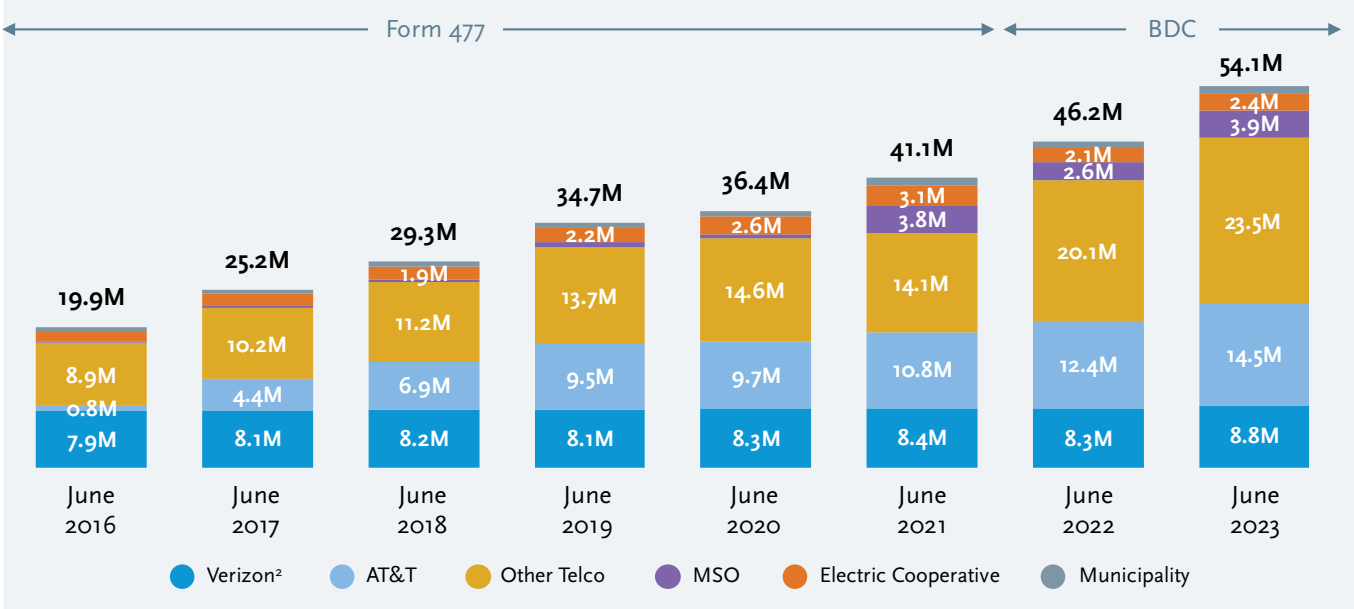
Despite regulatory obstacles in some states, municipal networks are gaining popularity. Cities are creating broadband networks to attract and retain residents, oftentimes stepping up where large providers have neglected to build. With the IIJA, municipalities also have a seat at the table to apply for BEAD and tap into federal funding opportunities.

Electric cooperatives are also finding success with fiber. Since entering the market, rural cooperatives are one of the fastest growing segments of broadband providers[4]. They are well positioned to deliver fiber via their existing infrastructure and won big with recent RDOF funding, giving them the financial boost to rapidly grow in passings. Perhaps most importantly, they're leading the way in bringing connectivity to the rural communities they operate in.

Fig 1.3

Fiber Deployments by Provider Type (2016 – 2023)

Total Fiber Locations Passed[1]



1. Includes double passings
2. Fluctuations in figures between years are likely due to quality issues in historical reported coverage.

Source: FCC Form 477 and Broadband Data Collection (BDC) filings, accessed 11/2023

Providers turn to expanding fiber access in more rural areas

Fiber deployment was traditionally associated with more densely populated areas which yield better returns thanks to lower costs per passing. This can be seen in the chart below: currently, 62% of urban locations have access to fiber, which is 16pp higher than the national average (46%).

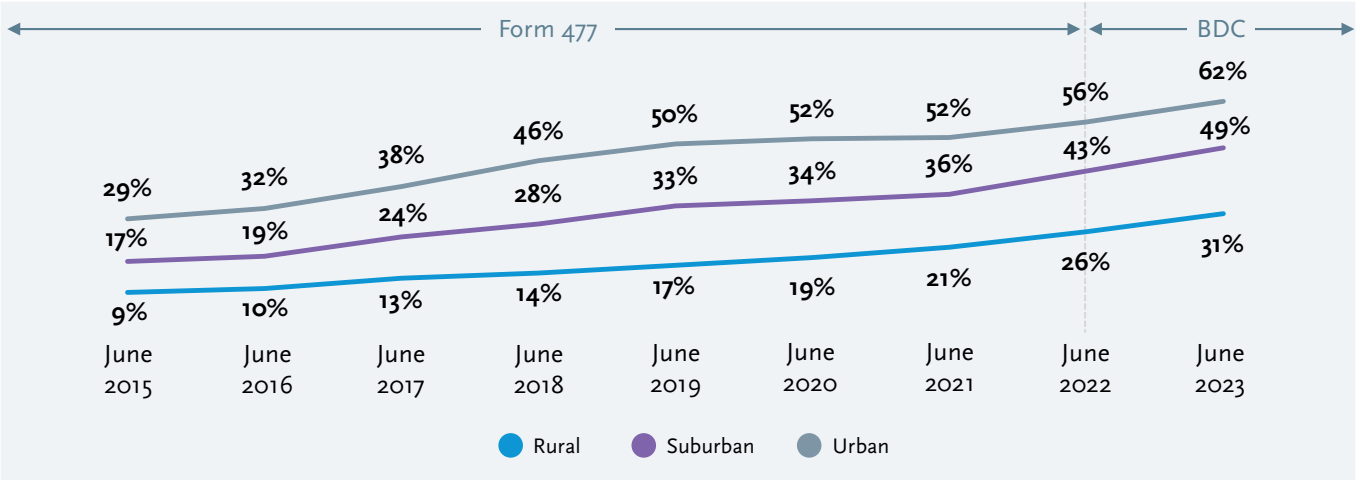
While rural areas still trail behind with fiber access, great strides have been made in recent years. As urban geographies have filled out with fiber, areas with less competition are becoming more attractive. The COVID-19 pandemic also drew national attention to gaps in broadband access and added renewed focus—and funding— to bringing fiber broadband to rural communities. Since June 2021, the pace of fiber deployment in rural areas has increased rapidly, raising access from 21% to 31% in June 2023. Despite this progress, rural coverage is still half that of urban. We can expect to see deployment strategies continue to make efforts to reduce this gap in the coming years.

[4] Fiber Broadband Association via Fierce Telecom

Fig 1.4

Fiber Coverage by Population Density[1] (2015 – 2023)

Share of Total Locations with Fiber Access



1. Rural is <100 locations per square mile, suburban is 101 – 2500 locations per square mile, urban is 2500+ locations per square mile
Source: FCC Form 477 and Broadband Data Collection (BDC) filings, accessed 11/2023

ILECs continued to lead the way on new fiber passings

In the midst of aggressive multi-year fiber rollout targets, some providers scaled back their deployment plans for 2023 while others made steady gains towards their longer-term goals.

AT&T leads the way among those making large investments in fiber, tracking towards 30M passings (residential and business) by the end of 2025. AT&T has been the biggest driver of fiber deployments in 2023 with 2.2M new consumer locations, despite management lowering expectations for the year[5]. AT&T reported strong Q3 results, citing 24M total passings (20.7M consumer, 3.3M business)[6].

Verizon, one of the early movers in the fiber space, has a target of 18M household passings by 2025[7]. If Verizon ends the year with the planned new 500K Fios locations, that leaves ~400K - 500K additional passings by 2025 to meet their goal[8]. Even with aggressive FWA plans, Verizon remains focused on markets where they can upgrade their infrastructure with fiber.

Other large providers reconsider their fiber rollout strategy for the coming years

Frontier, who made headlines in January for being the first major ISP to launch network-wide 5 Gig speeds, projected 1.3M new passings by year-end 2023, a 300K reduction from their original 2023 expectations[9]. This leaves 3.5M on the table to build over this year and next to hit their goal of 10M passings by 2025[10].

Last year Altice set a plan to reach 6.5M homes by the end of 2025 across its Optimum and Suddenlink footprints[11]. The company slowed its pace of new fiber locations in 2023 to 600K (down from 900K) and is evaluating at what pace they want

[5] AT&T Q4 2022 Earnings Transcript
[6] AT&T Q3 2023 Press Release
[7] Verizon Investor Day 2022
[8] Fierce Telecom
[9] Frontier Q1 2023 Earnings Call
[10] Fierce Telecom Frontier Exclusive
[11] Altice USA Q2 2022 Press Release

to continue their fiber strategy for 2024 and beyond[12]. As part of the revised strategy, FTTP upgrades will largely be focused on its tri-state urban environments.

Lumen reset its growth plans in June 2023 under new leadership, stating it would add 1M new locations each year starting in 2025 until reaching 7.4M locations by the end of 2027[13]. Lumen expects to build fiber to 500K locations by the end of 2023 to reach 3.6M total locations, with another 500K passings planned for 2024[14]. This 2024 estimate is revised down from previous projections by Lumen, noting the high cost of capital, but it's unclear if Lumen will update longer term plans.

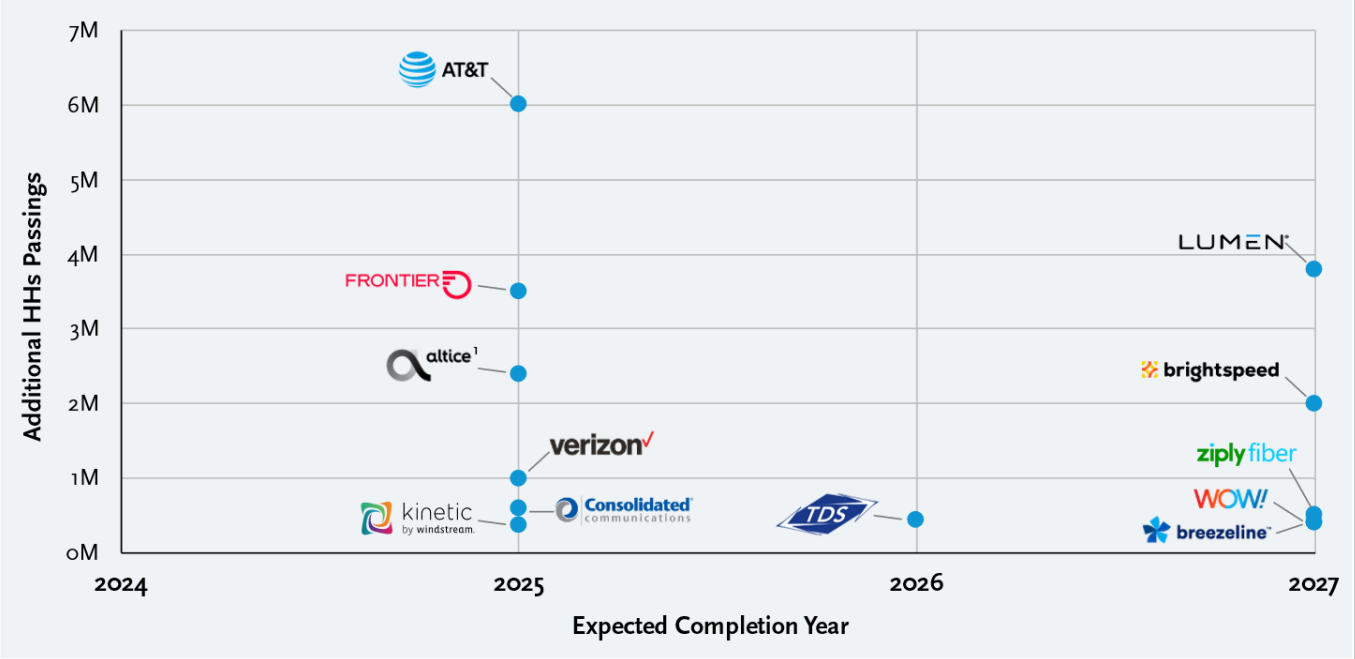
Regional providers continued to invest in fiber

Consolidated Communications slowed its build pace in 2023, stalling on its plan to upgrade 1.6M homes with fiber and moving away from a 2026 goal to complete its fiber upgrade. However, they remain invested in fiber says their CEO, leaning on fiber to boost subscribers and revenue[15]. They reported reaching around half of their addressable market with fiber by the end of 2023. TDS Telecom set a target of 175K homes to be passed with fiber in 2023, up from 133K in 2022. In Q3, TDS revised 2023 passings to 200K due to better-than-expected year-to-date results. Their long-term target remains 1.2M homes by 2026[16], nearly two-thirds of which they have now passed.

Fig 1.5

Fiber Deployment Announcements by Expected Completion Year

Footprint Expansion Plans as Additional Households



1. Altice expected to revise their fiber deployment target
Source: Company press releases, public filings as of 11/2023

[12] Altice USA Q3 2023 Earnings Call
[13] Lumen June 2023 Investor Day
[14] Lumen Q3 2023 Earnings Call
[15] Consolidated Communications Q2 2023 Earnings Transcript
[16] TDS Telecom

States collaborated with their broadband communities on NTIA submissions

2023 was a big year for states in preparing for BEAD. States started the year building a Five-Year Action Plan. The NTIA announced final funding allocations in June of 2023, divvying up the program's $42.45B between the 56 states and territories. The notice of available funding amounts issued in June started a 180-day timer for states to submit their Initial Proposals by late December[17]. Initial Proposals required states to seek collaboration in developing their BEAD strategies, and many officials busied themselves this year with listening tours and other forms of community engagement.

States are now turning their attention to the competitive subgrantee process, which can be initiated after NTIA approval on Initial Proposals and initial funding requests (20% of total funds). The outcome of the selection process, along with additional local coordination efforts, will be documented in states' Final Proposals, which are due in late 2024/early 2025.

NTIA considered adjustments to BEAD requirements amid industry concern

The BEAD program also underwent some revisions in 2023. In November, the NTIA modified its letter of credit (LOC) requirement after facing pushback that the provision could prevent smaller ISPs from participating in BEAD. The rule required applicants to hold 25% of the grant amount in a cash account, evidenced by a LOC from a traditional bank. With the newly published waiver, applicants now have alternative financing options that provide more flexibility in where they can get a LOC from and the obligated amount[18].

NTIA also entertained discussions on the Build America Buy America ("BABA") Act stipulations tied to federally funded programs including BEAD. BABA requires that items are manufactured in America and at least 55% of components are sourced in America[19]. The broadband industry expressed concerns about meeting these requirements, particularly for electronics. In response, the NTIA proposed a BABA waiver that relaxed requirements around electronics sourcing while still promoting onshore assembly[20]. In the meantime, many key US manufacturers have ramped up domestic production to meet the Buy America requirements, including Adtran, CommScope, Corning, and Nokia[21].

The broadband industry started evaluating BEAD grants

While states are preparing their subgrantee selection processes, many service providers are already weighing their options for BEAD. In speaking with providers, we found many have started to evaluate BEAD opportunities in and near their footprints, considering both the costs and the capacity to deliver.

From a capacity point of view, many players anticipate a shortage in skilled labor once subgrant awards are made. As part of the effort to address the skills gap and worker shortage, Fiber Broadband Association's OpTIC Path Program is currently engaged with 40 states, 44 service providers, and 70 community colleges, and graduated 209 participants in 2023. That figure is expected to grow substantially as more places adopt and deliver OpTIC Path nationwide.

[17] NTIA Internet for All
[18] NTIA Letter of Credit Waiver
[19] US Department of Commerce
[20] US Department of Commerce
[21] Fierce Telecom

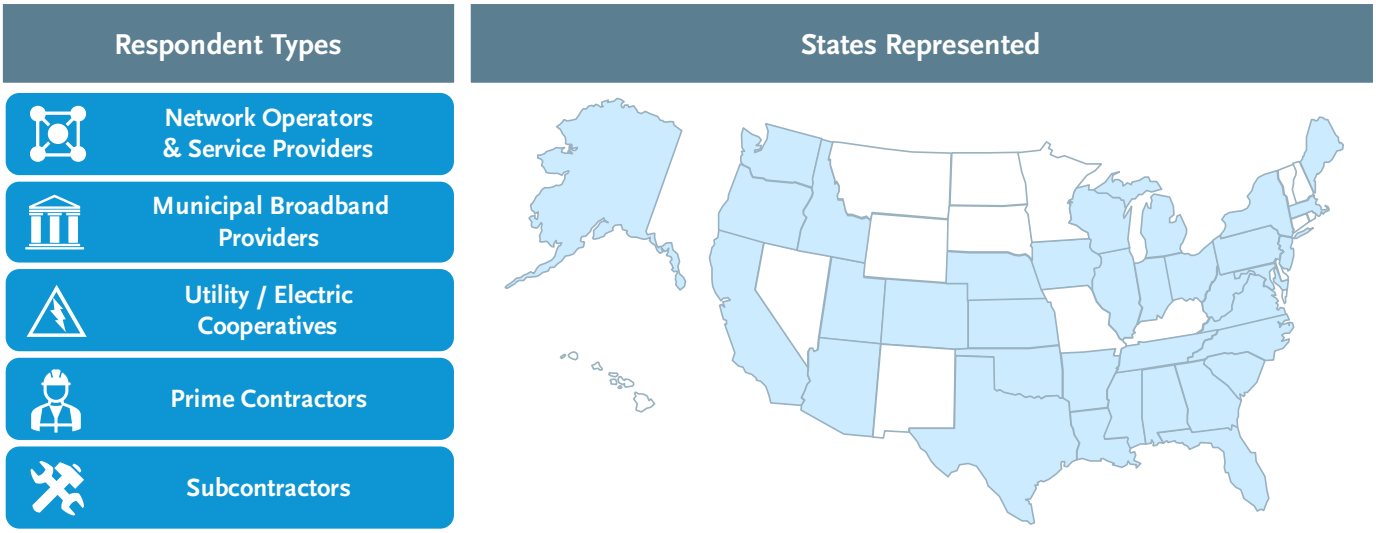
SECTION 2: FIBER DEPLOYMENT COSTS

In this section we review the findings of the 2023 study on fiber deployment costs.

Despite billions of dollars of investment in fiber networks, finding reliable and accurate cost data can be challenging. Furthermore, there is limited insight available on how costs are evolving over time.

To address these knowledge gaps, the Fiber Broadband Association commissioned Cartesian to conduct research across the industry. Responses were collected via phone interviews and online survey in October and November 2023.

Cartesian received input from across the industry and nation. Respondents spanned the fiber construction ecosystem from traditional providers to contractors and represent 35 states in total based on primary deployment locations. The results from our study provide a snapshot of deployment costs in different scenarios. The reported costs may not be representative of all providers' costs or circumstances and should not be interpreted as such.



Source: Fiber Broadband Association, Cartesian

The fiber deployment study looks at a range of deployment scenarios

Planning this study required care as fiber deployment costs are dependent on many factors and, as no two deployments are ever the same, costs can vary widely between jobs.

To enable meaningful comparison within the study, each participant was asked to characterize their build environment and primary construction method; costs for labor and materials were reported as unit costs (cost per foot); and costs for items such as engineering, design, permitting, and make-ready were excluded from these metrics.

Although not the focus of this study, respondents estimated that engineering, when sourced externally, generally ends up around 2% - 10% of total project cost.

Permitting can vary, depending on who holds the right of way. For those that paid for permits, respondents reported costs around 10% of the overall project.

Deployment Cost Drivers

Build Environment

Physical features, natural and humanmade, of the area for fiber deployment

- Survey Focus — Location
- Survey Focus — Infrastructure Availability
- Survey Focus — Topography / Terrain
- Survey Focus — Housing Density
- Local Regulations & Requirements

Construction Method

Technique used for deploying fiber, largely influenced by build environment

- Survey Focus — Hanging Fiber *Aerial*
- Survey Focus — Trenching *Underground*
- Survey Focus — Microtrenching *Underground*
- Survey Focus — Plowing *Underground*
- Survey Focus — Directional Boring *Underground*

Input Costs

The actual cost components that make up total deployment cost

- Survey Focus — Labor
- Survey Focus — Materials
- Permitting
- Make Ready Costs
- Engineering & Design

Source: Fiber Broadband Association, Cartesian

The cost per foot of aerial deployment is less than half that of underground

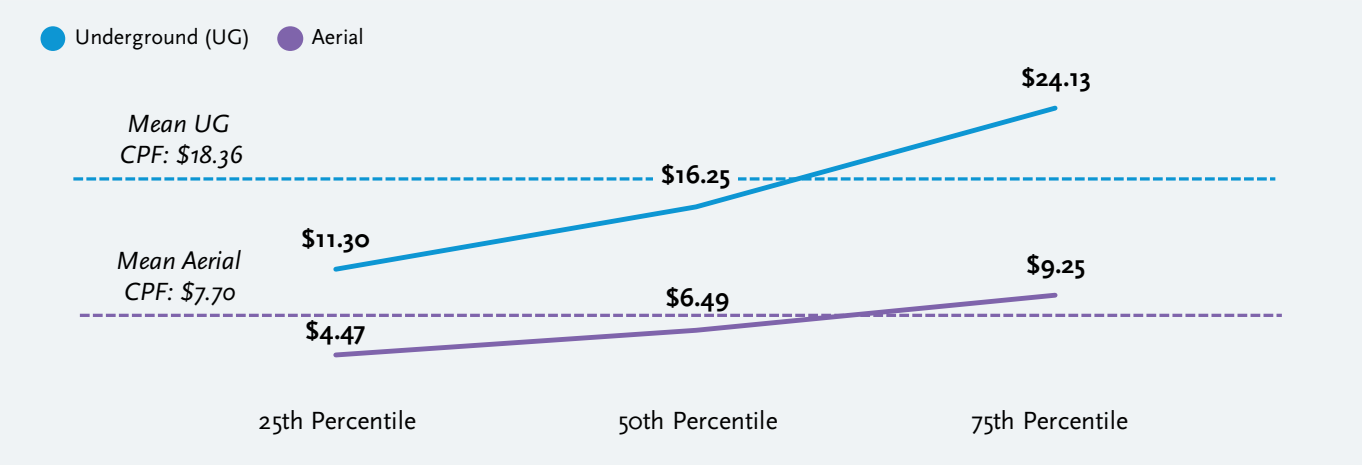
The study compared the cost of aerial and underground construction methods. Most respondents (70%) used a combination of both, with 25% reporting underground-only and only 5% being exclusively aerial.

From a cost point of view, the unit cost of underground construction is significantly higher than aerial. The median cost for underground deployments within the study was $16.25/ft versus $6.49/ft for aerial. In both cases – aerial and underground – there was a wide cost range, with costs at the 25th percentile being less than half those of the 75th percentile. We explore reasons for the wide range of costs later in this report.

Fig 2.1

Deployment Cost Interquartile Ranges

Cost per Foot, Labor and Materials Only



Source: Fiber Broadband Association, Cartesian

Interviewees' choice of using underground or aerial construction was driven by factors including access to poles, upfront and ongoing costs, the risk of cable breaks, and speed of deployment.

Underground cabling was viewed as more resilient and better protected against accidental damage and adverse weather events such as tornados, high winds, ice storms, and forest fires. The option to dig is also almost always available, whereas aerial requires poles.

Where poles are available and access can be secured on reasonable terms, the economics of aerial deployment can be attractive. Aerial also benefits from being less intrusive than underground construction and enables faster roll-out.

For entities that own their own poles, including municipals and electric co-ops, re-use of this infrastructure has many advantages. Firms seeking access to others' poles noted that make-ready costs can vary significantly, and in some cases may make underground a better option. Study participants estimated that make-ready costs can add $5 to $6 per foot to the unit costs; other estimates ranged from $500 to $5,000 per pole depending on the amount of rework required, for example, to reposition power lines.

It's also worth noting that operating expenses tend to be higher for aerial fiber due to more frequent cable breaks. One provider noted that these additional costs lead to underground and aerial costs being comparable when viewed on a longer-term, total cost basis. Because of this, and the customer service issues related to cable breaks, this provider favored underground deployment.

Costs per home passed were mostly between $700 and $2700

In addition to analyzing unit costs for construction, we also investigated the cost per passing in aerial and underground builds.

The reported cost per home passed (CPHP) for underground deployments ranged from $1.6K to $2.6K ($25^{th}$ to 75^{th} percentile range); the more expensive passings tended to come from more rural areas.

The CPHP for aerial deployments was lower than those of underground, ranging from under $700 to $1500 for respondents in suburban and urban environments, and $1.3K to $2.7K in more rural areas.

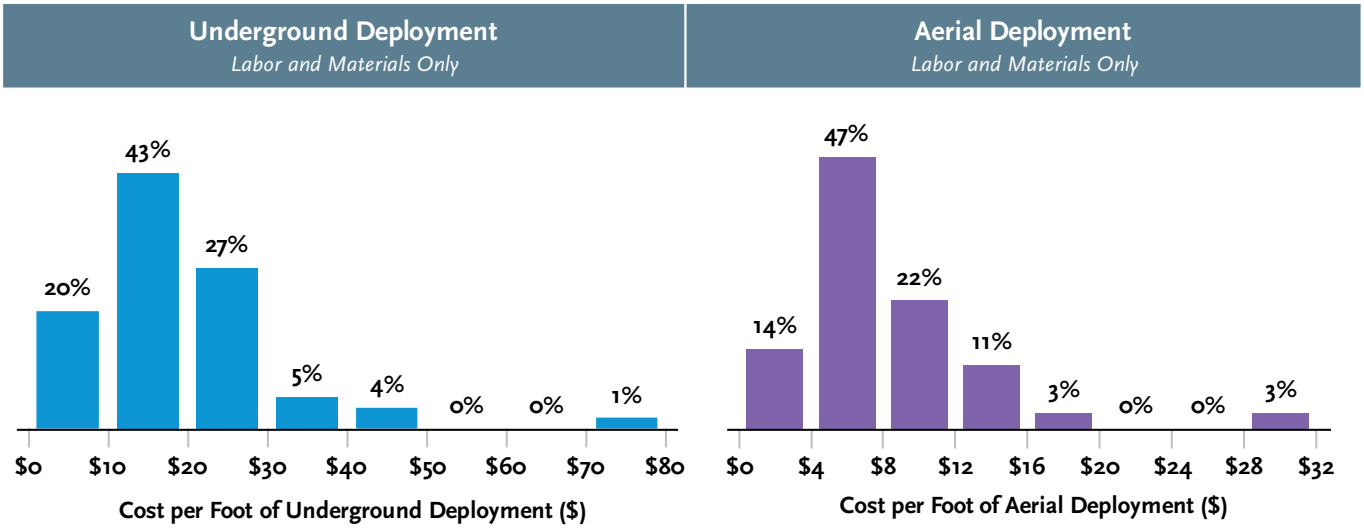
When comparing CPHP across builds it can be difficult to identify whether cost differences are simply due to the distance between homes or some other factor. Elsewhere in the report we use unit costs per foot to enable like-for-like comparison.

Outliers in the reported costs are many times higher than the average

As noted above, both aerial and underground builds have a wide range of costs. The chart below shows the distribution of responses in the study.

Fig 2.2

Deployment Costs Distribution



Source: Fiber Broadband Association, Cartesian

For underground, the highest share of responses fell between $10 and $20 (43%); the majority of respondents (63%) had costs of less than $20/ft and almost all (90%) were under $30/ft. Notably, there were some cases where costs were significantly higher – above $70/ft at the top end. The most expensive builds were due to local factors such as navigating waterways or challenging underground situations in dense urban areas.

For aerial, most respondents (75%) reported costs of $10/ft or less. In fact, over half were between $4/ft and $8/ft. As with underground, there were some more expensive outliers, with the highest reported costs reaching $30/ft or more.

Labor accounts for over two-thirds of build costs

To understand the costs in more detail, respondents were asked to report labor and materials costs separately.

Across all responses, labor was the dominant cost, accounting for at least 50% and up to 90% of reported unit costs. On average, labor contributed 73% of the underground build cost and 67% of aerial.

Given labor's share of cost is roughly twice that of materials, it is understandable that network builders will seek efficiencies here. As we show later in the report, the construction method has a large bearing on cost and more efficient techniques enable construction crews to faster cover ground.

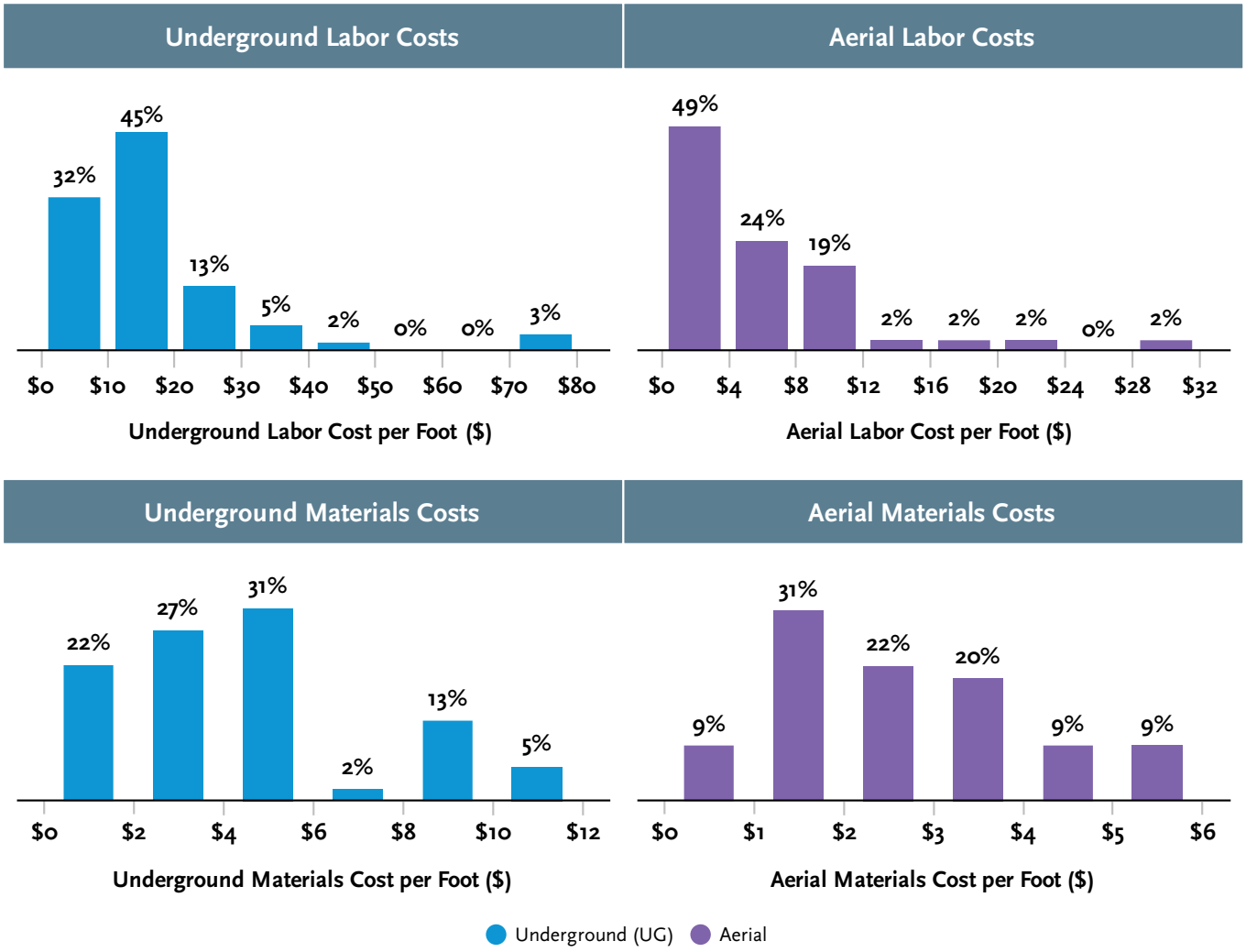
Looking at the distribution of labor and materials costs in the chart below, it's clear that the labor drives the long tail of higher unit costs seen above. The labor costs for both aerial and underground show a similar long tail, whereas the material costs are more closely clustered.

The median underground labor cost was $12.15/ft and in most cases (90%) was no more than $30/ft. For aerial, the median was $4/ft with most (92%) less than $12/ft.

For materials, costs ranged up to $6/ft for aerial and $12/ft for underground. The median underground materials cost was double that of aerial ($4/ft and $2/ft respectively).

Fig 2.3

Deployment Input Costs Distribution



Source: Fiber Broadband Association, Cartesian

Population density has a large impact on the cost per foot of underground builds

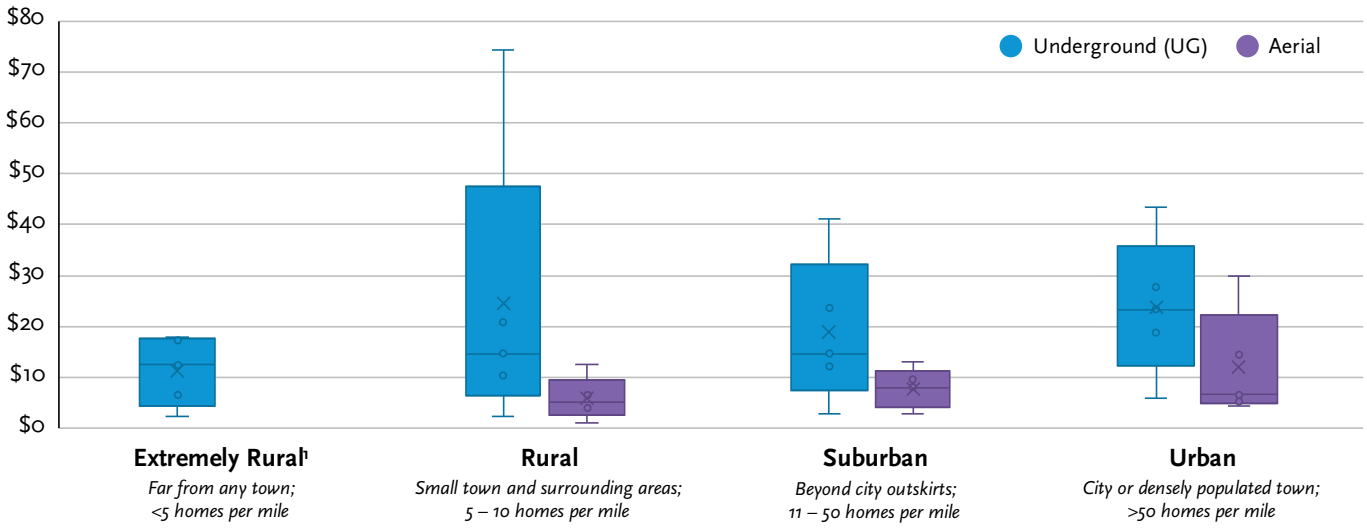
Population density is one of the key factors in a fiber business case; however, this is typically viewed from the perspective of the footage required to pass each home. In this study, the focus is on how population density impacts the unit cost per foot.

The study found a correlation between higher density and higher cost. For underground deployments, urban areas had the highest median cost ($23.25/ft) around half that of extremely rural areas ($12.50/ft). Rural areas also had the lowest median cost for aerial deployments at $5.00/ft, although for aerial, the suburban median cost was higher than that for urban ($8.00/ft vs. $6.54/ft).

Fig 2.4

Deployment Cost Ranges by Population Density

Cost per Foot, Labor and Materials Only



Median:

	Extremely Rural[1]	Rural	Suburban	Urban
UG	**$12.50**	**$14.63**	**$14.59**	**$23.25**
Aerial	**-**	**$5.00**	**$8.00**	**$6.54**

Note: Box represents range between 25th and 75th percentiles and whiskers show full range of responses
1. Limited data for extremely rural aerial deployment
Source: Fiber Broadband Association, Cartesian

Factors driving underground costs up with increasing population density include surface type which is more likely to be a road or sidewalk: not only are these surfaces more costly to install into than dirt, but they also have higher reinstatement costs. Also, beneath the surface, builds in more dense areas are more likely to encounter other utilities which can limit the use of backhoes and other machinery.

It's worth noting that across the density categories the cost ranges overlap. In some cases, low density areas reported higher costs than areas that were more dense.

Where available, a choice of construction method can reduce cost

For underground builds, there are a variety of construction methods available, each occupying their own niche. Study participants reported using directional boring, trenching, micro-trenching, and plowing. Where construction was contracted out, the choice was often left to the subcontractor.

A description of the most common methods is provided in the table below.

Construction Method	Description	Key Advantages
Boring	• Horizontal hole (~2" to 6" diameter, 3' to 5' deep) created via boring machine • Creates a straight path tunnel to install conduit • Push casing through borehole as it's being dug	• Requires less sophisticated (and therefore cheaper) machinery • Ideal for shorter distances and wider variety of soil types
Directional Boring	• Horizontal hole (~2" to 6") drilled 3' to 5' deep with a steerable surface level drill • Creates a tunnel in desired direction under the roadway/surface to install conduit	• Efficient for long distances • Useful when there's limited space • Minimizes disruption to infrastructure and environment
Trenching	• 2" to 6" wide cut trench, 2' to 6' deep via a chain blade and pulled through by a tractor • Conduit/cable paced at bottom of the cut • Trench is reinstated through compaction of removed spoils	• More visibility of the work area allowing for easier installation • Allows for easy future expansion
Microtrenching	• Narrow trench, up to 2" and no deeper than 18" • Conduit laid directly into the trench within a roadway • Routed through/undercurbs or into surface vaults	• Advantageous for urban environments • Speed minimizes disruptions to traffic flow • Requires less aesthetic restoration
Plowing	• 2" to 6" wide slice made 2' to 4' deep with a blade and pulled through with a tractor • Conduit/cable paced at bottom of the slice and covered with cutting spoils	• Beneficial when there's no obstacles along route and in softer soil environments • Creates less disturbance to surface area

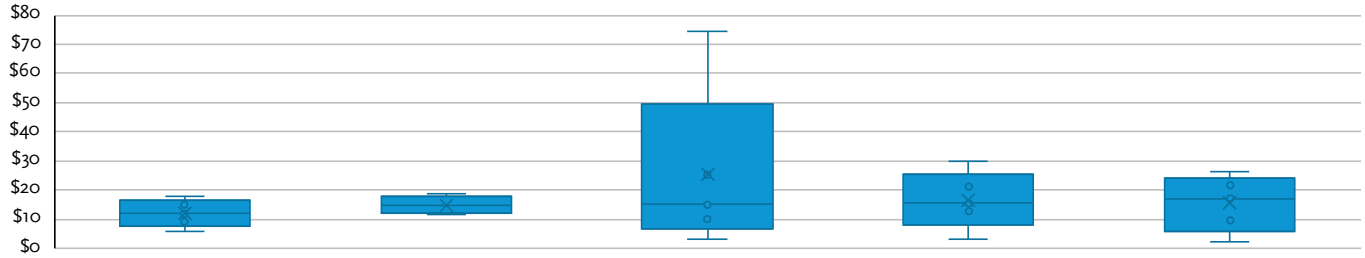
Respondents were asked to identify the primary construction method employed on their projects. For those with no clear prime, responses were categorized as using a combination of methods.

Trenching had the lowest median cost at $12.00/ft, followed closely by microtrenching at $14.51/ft. Directional boring was higher at $15.10/ft but had the widest range of reported costs, especially on the higher end. Surprisingly, plowing had the highest reported median cost, but the upper range of plowing costs were fairly in-line with or below other methods.

Fig 2.5

Underground Deployment Cost Ranges by Primary Construction Method

Cost per Foot, Labor and Materials Only



	Trenching	Microtrenching	Directional Boring	Combination of Methods	Plowing
Median:	**$12.00**	**$14.51**	**$15.10**	**$15.50**	**$17.00**

Note: Box represents range between 25th and 75th percentiles and whiskers show full range of responses
Source: Fiber Broadband Association, Cartesian

As mentioned above, given the share of labor costs in deployment, choice of construction method can offer a path to optimize costs.

Building in rocky areas costs twice as much as laying fiber in soft earth

Respondents were also asked to identify the primary terrain type encountered for underground deployment. They were given the option to select from soft earth, hard clay, sandy, wetlands, rocky, or a mix of terrains.

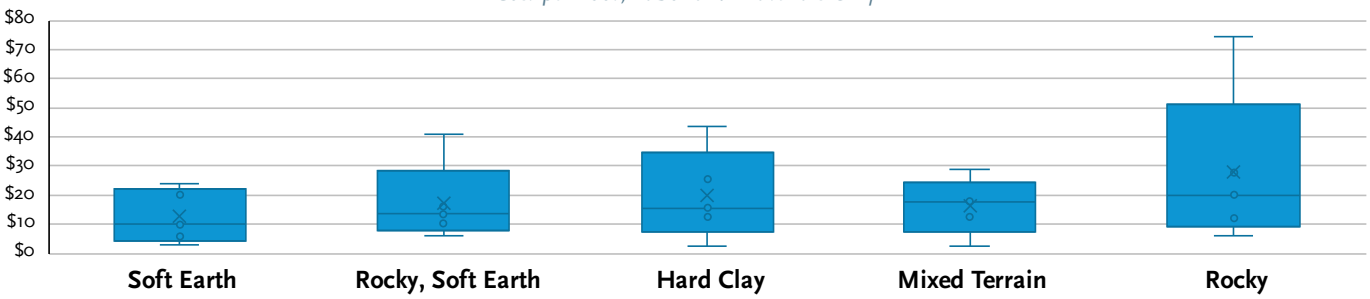
As anticipated, reported costs were higher for hard ground and rocky areas. Rocky terrain tends to be expensive as it requires more cutting/drilling and progress is slower. In fact, the median cost for rocky terrain was double that of deploying in soft earth ($20.00/ft versus $10.00/ft).

Rocky ground also had the longest tail of higher costs, accounting for the top-end of reported underground costs at over $70/ft.

Fig 2.6

Underground Deployment Cost Ranges by Terrain Type

Cost per Foot, Labor and Materials Only



	Soft Earth	Rocky, Soft Earth	Hard Clay	Mixed Terrain	Rocky
Median:	**$10.00**	**$13.50**	**$15.50**	**$17.85**	**$20.00**

Note: Box represents range between 25th and 75th percentiles and whiskers show full range of responses
Source: Fiber Broadband Association, Cartesian

The Western states had the highest cost ranges

Given the impact on cost by terrain type and population density, one may expect to find regional differences in reported deployment costs. The map below shows that this was indeed true.

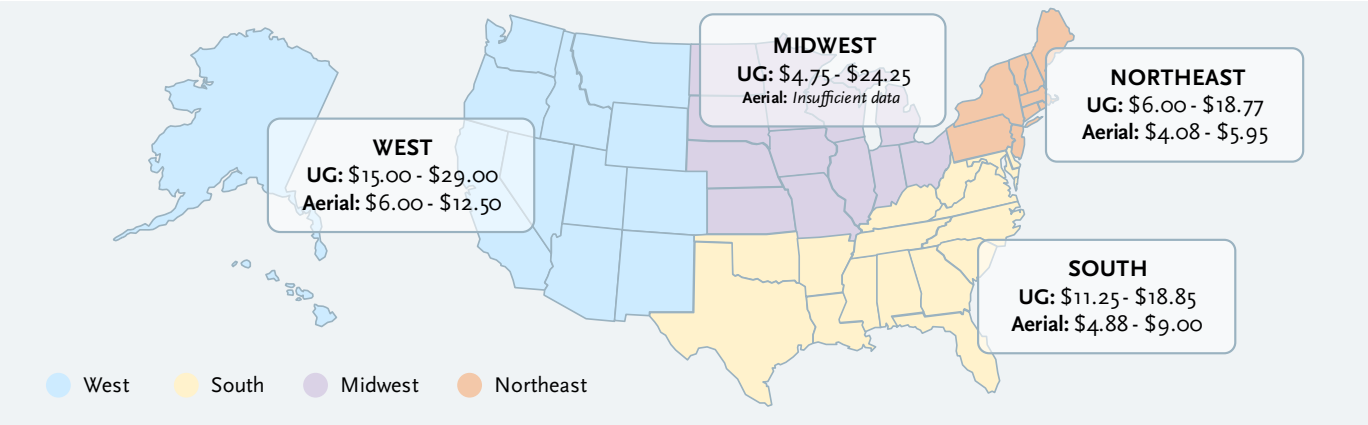
Cost ranges in the West were the most expensive and the Northeast was the least expensive for both aerial and underground. The Midwest had the widest range of underground costs, with respondents reporting both lower and higher costs than elsewhere.

Regional cost variations are most likely due to topography and the extent of rocky ground, which we have seen heavily impacts underground builds. This is also likely to explain why regional differences are more pronounced for underground construction than aerial.

Fig 2.7

Deployment Cost Ranges by Region

25th – 75th Percentiles for Cost per Foot, Labor and Materials Only



Source: Fiber Broadband Association, Cartesian

Customer connection costs vary by location but tend to be predictable

The focus of the preceding sections was on the cost to pass premises (on a cost per foot basis) in rolling out a network. Respondents were separately asked to report the average cost of connecting customers. This is commonly referred to as the "drop cost" and, for the purposes of this study, the cost of ONTs and other CPE is excluded.[22]

Reported costs varied by the length of the drop[23] and whether it was aerial or underground. Longer drops (101- 500 feet) and underground drops had higher median costs than those that were shorter and/or aerial.

Across all drop lengths, underground drop costs typically fell between $575 and $1,200, whereas aerial ranged from $312 to $833 for most respondents.

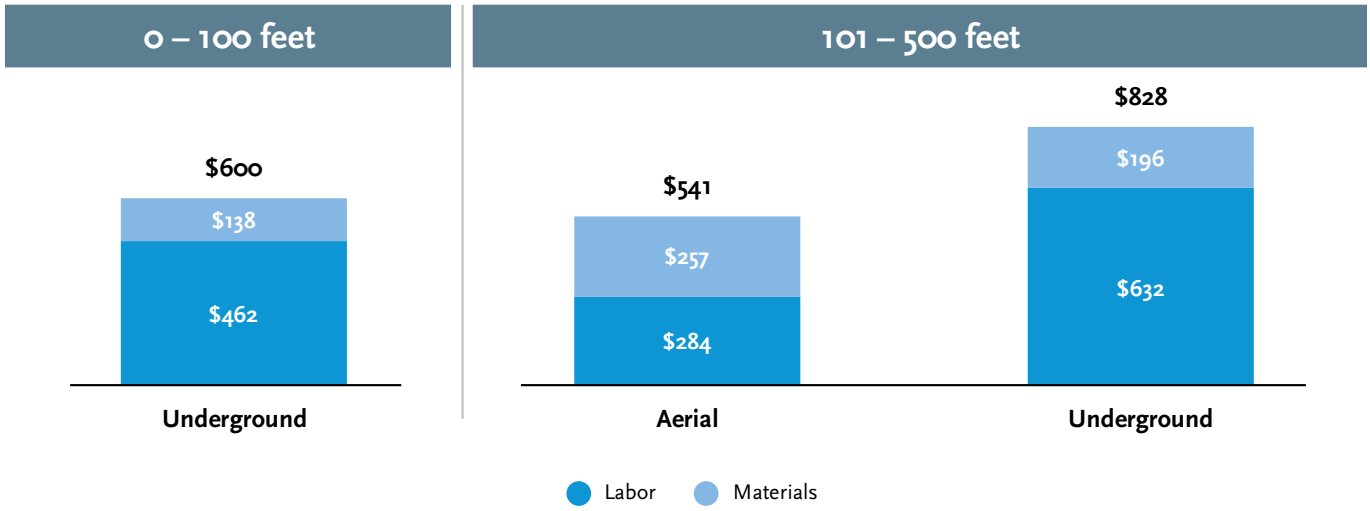
In the 101 – 500 feet category, aerial drops had a far lower median cost ($541.00) than underground drops ($827.50). The costs of materials were broadly similar across aerial and underground, but labor costs were much higher. This can also be seen in the composition of drop costs—labor accounted for a larger share of underground drops (76%) than aerial (52%).

[22] Depending on the technology involved, ONT and equipment costs were cited anywhere from $100 to $300 per premises.

[23] For average drop length, respondents were asked to pick one of three categories: 0 – 100 feet, 101 – 500 feet, and 500+ feet. There were insufficient responses recorded for the 500+ feet category.

Fig 2.8

Median Costs per Drop (CPD) by Drop Length



Source: Fiber Broadband Association, Cartesian

While drop costs can vary between premises, these appear to be of lesser concern to study participants. Drop costs were reported to be more predictable, with fewer unforeseen problems.

SECTION 3: COST TRENDS

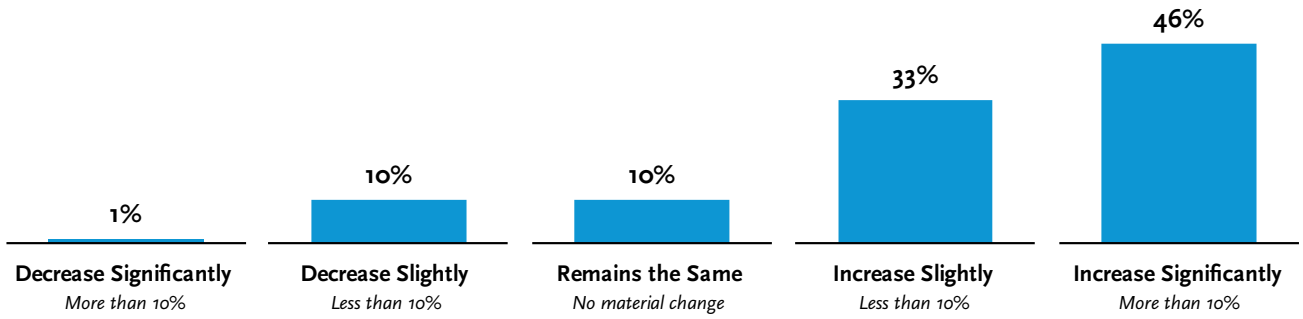
Almost half of respondents reported significant cost increases in the past year

When asked to what extent deployment costs had changed from 2022 to 2023, most respondents (79%) reported that costs had increased. Of those with rising costs, the majority reported increases of at least 10%.

Fig 3.1

Reported YoY Deployment Cost Changes (2022 – 2023)

Change in Deployment Costs from Last Year to Current Year by Level of Change



Source: Fiber Broadband Association, Cartesian

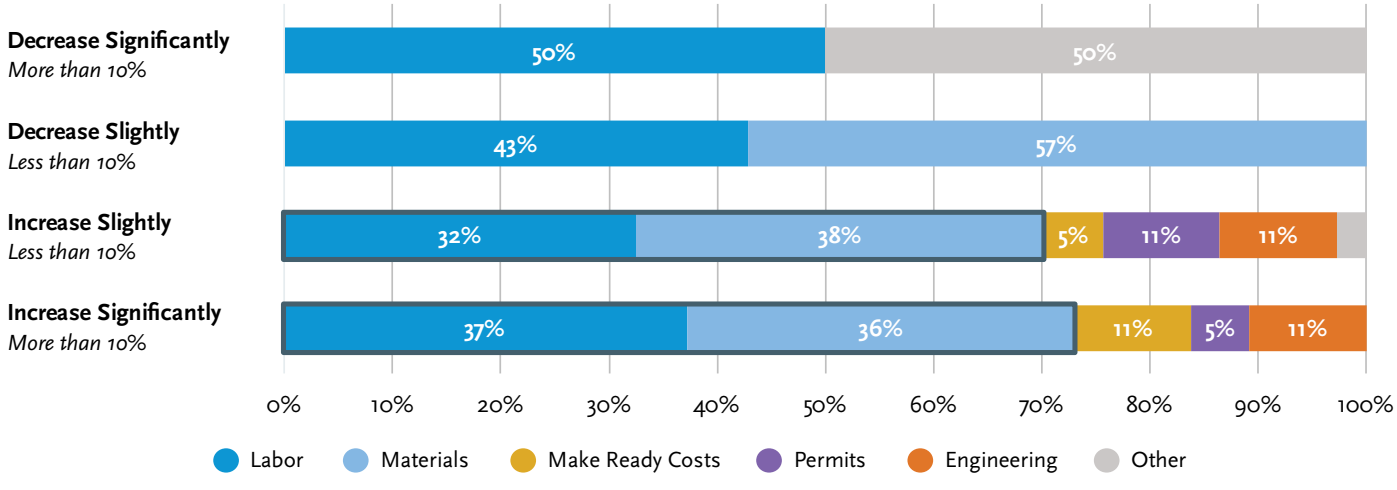
When asked to identify the primary driver of the cost difference, those that reported cost increases most often cited labor and materials as reasons for higher costs. Labor was cited 37% of the time and materials 36% of the time among those with "significantly" higher costs. Similarly, labor was cited 32% of the time and materials 38% of the time among those with "slightly" higher costs.

For underground deployments, engineering and permitting were the third and fourth most cited driver of cost increases. For aerial, make-ready was the third most cited driver at 13% of the time among those with significant increases and 7% for those with slight increases.

Fig 3.2

Identified Drivers of Reported Cost Changes

Reported Cost Change (Current Year vs. Last Year), 2022-2023



Source: Fiber Broadband Association, Cartesian

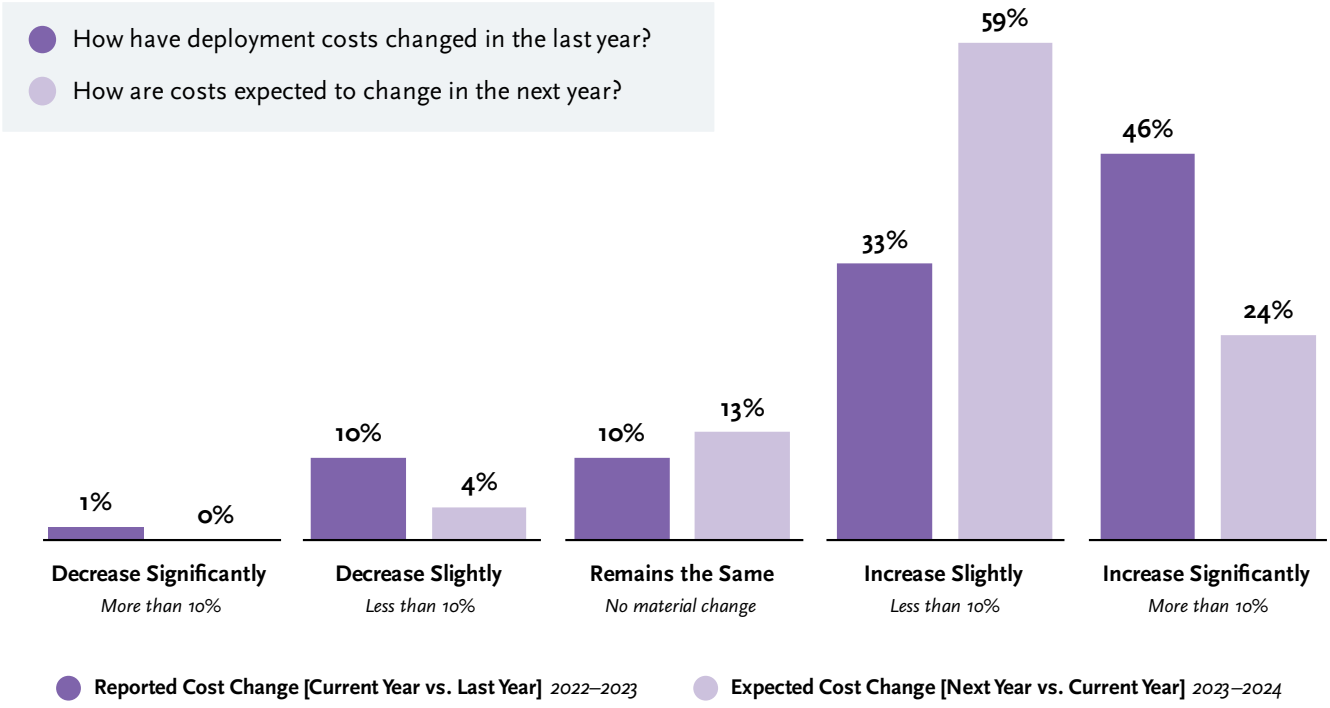
Costs are expected to increase over the next year, but less steeply than before

Looking to 2024 and beyond for fiber deployment, there are reasons to be optimistic on cost. When asked how deployment costs are expected to change from 2023 to 2024, survey participants generally anticipate costs to increase less than last year.

While 46% of respondents reported "significant" cost increases last year, only 24% expect the same in 2024. Most respondents (59%) predict a slight price increase (less than 10%) and 13% expect costs to remain the same.

Fig 3.3

Reported vs. Expected Annual Deployment Cost Changes



Source: Fiber Broadband Association, Cartesian

Labor and materials remain the main reasons for cost increases

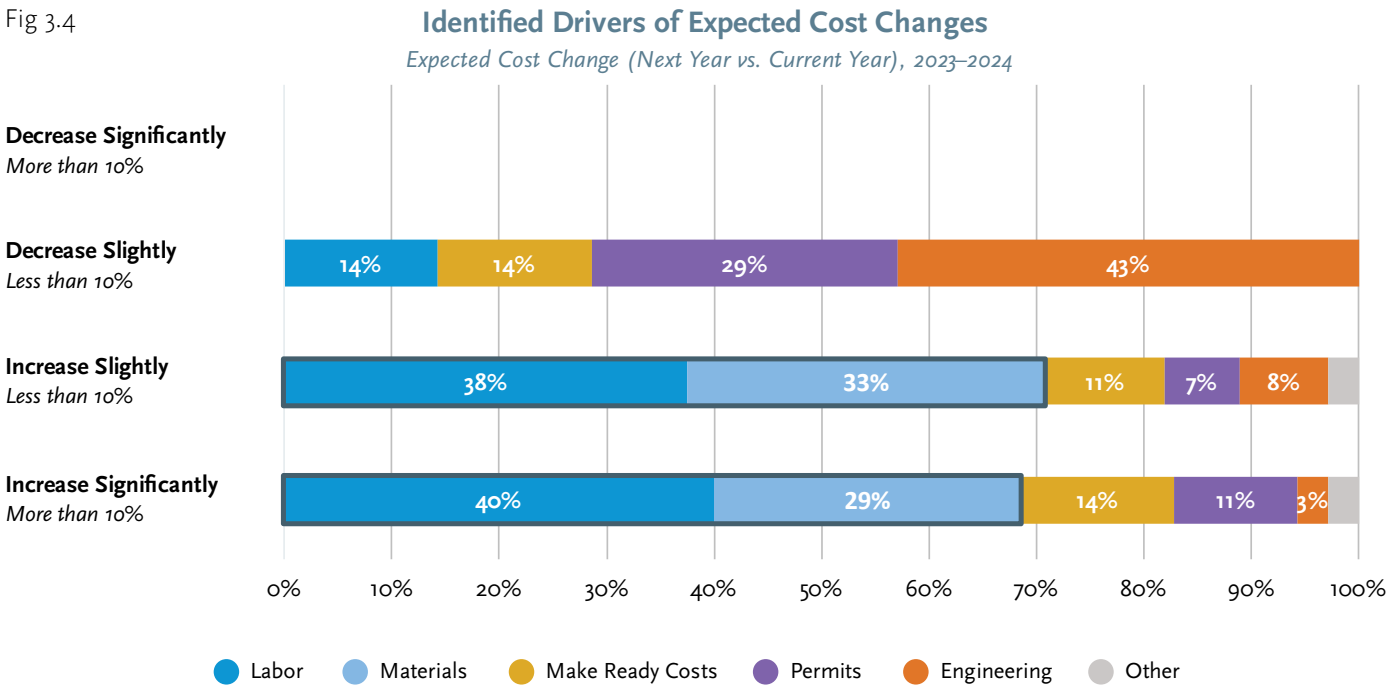
Labor and materials were most commonly cited as the reason for the expected cost increases in 2024. 40% of responses expecting a significant rise (greater than 10%) and 38% of responses expecting a slight rise (less than 10%) called out labor as the key driver. Material costs were placed second, cited in 29% of responses expecting a significant increase and in 33% that anticipate a slight increase.

Make-ready costs were identified more frequently as a driver of future cost changes than in the year before. Interestingly, this was both as a driver of higher costs (11% - 14%) and a driver of lower costs (14%). Those anticipating lower costs may be encouraged by the FCC's recent proposal to reform pole attachment rules and policies.[24]

[24] Fourth Report And Order, Declaratory Ruling, And Third Further Notice Of Proposed Rulemaking FCC, WC Docket No. 17-84 (Nov. 22, 2023)

For those that answered "other", the fill-in responses typically referenced macroeconomic conditions and other fees associated with fiber construction.

Fig 3.4



Source: Fiber Broadband Association, Cartesian

CONCLUSION

There's a bright outlook for fiber deployment in 2024

Despite the potential for costs to creep higher, there's reason to remain bullish on fiber rollouts. The pace of fiber deployment is expected to remain strong in 2024, bolstered by improved economic conditions and preparation efforts.

Hopefully the worst of high inflation and interest rates are now behind us. If these indicators hold, we'll have a better macroeconomic environment for large investments like deploying fiber.

Inflation aside, the sheer amount of federal funding coming into the industry starting this year will spur deployment. After states spent most of 2023 planning for dispersing the incoming BEAD dollars, 2024 will kick off the process of funds flowing through states to subgrantees. While the bulk of funding most likely won't make its way to providers until 2025 or later, we expect early BEAD projects to break ground towards the end of this year. Public funding also makes the fiber market more attractive for private equity investors, and we can expect to see private investment continue to back the market and drive deployments.

In addition to widespread funding availability, the industry is looking at ways to improve logistics to reduce roadblocks and clear the path for deployment. The aforementioned effort to reform pole attachment and make-ready rules is one such example. These reforms would redefine the processes for managing bulk attachment requests and allocating replacement costs. If adopted, providers could expect fewer, less costly delays to hang fiber.

Supply chain preparations are also necessary to handle the influx of demand for construction inputs. Manufacturers have ramped up domestic production in response to BABA requirements for BEAD, easing some concerns over supply availability.

Looking ahead, the industry is well-suited to deliver on promises to close the digital divide and we'll continue to see fiber used to upgrade networks, expand internet access, and meet consumer needs in the upcoming year.