Report of the Tennessee Advisory Commission on Intergovernmental Relations

Broadband Internet Deployment, Availability, and Adoption in Tennessee

January 2017

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Report of the Tennessee Advisory Commission on Intergovernmental Relations

Broadband Internet Deployment, Availability, and Adoption in Tennessee

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State of Tennessee

Tennessee Advisory Commission on Intergovernmental Relations
226 Capitol Boulevard, Suite 508
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January 26, 2017

The Honorable Randy McNally
Lt. Governor and Speaker of the Senate

The Honorable Beth Harwell
Speaker of the House of Representatives

Members of the General Assembly

State Capitol
Nashville, TN 37243

Ladies and Gentlemen:

Transmitted herewith is the Commission's report on broadband deployment, availability, and adoption in Tennessee, prepared at the request of the Commission in response to questions raised by Chairman Mark Norris. The request asked the Commission to study the current status of broadband deployment, availability and adoption in the state, assess where there are gaps in coverage, evaluate best practices in other states for encouraging deployment and adoption, and recommend ways that Tennessee can increase broadband availability and adoption in the future.

The Commission's research has found that there are already several government and private initiatives to address both access and adoption, supporting the recommendation that Tennessee should focus its efforts on supporting and coordinating these existing initiatives and on addressing any remaining coverage and adoption gaps. Any government response should focus on working with the private sector—both for-profit and non-profit—to fill these gaps in the manner least costly to taxpayers without expanding the role of government. The report also includes several supplemental recommendations for encouraging broadband adoption, expanding coverage, and facilitating coordination and planning. The report was approved by the Commission on January 26, 2017, and is hereby submitted for your consideration.

Respectfully yours,

Senator Mark Norris
Chairman

Cliff Lippard
Executive Director

The Tennessee Advisory Commission on Intergovernmental Relations

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MEMORANDUM

TO: Commission Members

FROM: Cliff Lippard
Executive Director

DATE: 26 January 2017

SUBJECT: Broadband Internet Deployment, Availability, and Adoption in Tennessee—Final Report for Approval

The attached commission report is submitted for your approval. Staff has continued to refine the information and recommendations presented in the report to address questions and feedback from members at the December 2016 meeting.

As noted in the draft report, approximately 89% of Tennesseans live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 25/3 according to data collected by the Federal Communications Commission (FCC) in December 2015. More than 93% live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 10/1. We have clarified in the report that this represents the maximum extent of wireline and fixed wireless broadband coverage as of December 2015. The data do not say whether everyone in these census blocks has access to service at the reported capacities, nor do the data include coverage expansions that have occurred since. While only 40% of households located in census blocks where providers reported offering at least 25/3 broadband subscribed to the service according to the FCC's 2016 Broadband Progress Report, we have also clarified that it is possible that the state's adoption rate is higher than reported by the FCC because, again, the data do not say whether everyone in these blocks has access to service.

The Commission's research has found that there are already several government and private initiatives to address both broadband access and broadband adoption. Based on these existing resources, the report makes the following recommendation:

- ***Tennessee should focus its efforts on supporting and coordinating these existing initiatives and on addressing any remaining coverage and adoption gaps. Any government response should focus on working with the private sector—both for-profit and non-profit—to fill the gaps in the manner least costly to taxpayers without expanding the role of government.***

The report makes several supporting recommendations to encourage more Tennesseans to adopt service:

- Tennessee's local library system is an existing resource that is positioned to help residents improve their digital literacy skills and learn about the ways they can benefit from broadband. The Tennessee State Library and Archives (TSLA) has adopted technology services guidelines that call for all libraries serving at least 5,000 patrons to offer meeting space and devices to community organizations for digital literacy training. Libraries are also encouraged to provide digital literacy training several times a year depending on size, ranging for once per quarter for smaller libraries to twice per month for larger libraries. ***Increasing funding so that all libraries meet TSLA's guidelines would improve access to digital literacy resources throughout the state and could assist communities that want to implement programs for encouraging broadband adoption.*** Ensuring that all libraries meet TSLA's guidelines would cost approximately $144,640 per year, according to TSLA.
- Further, 18 libraries throughout the state are addressing the affordability gap in their communities by lending hotspot devices that allow patrons to access wireless broadband. Providers offer hotspot devices to libraries at no cost, while monthly broadband service costs approximately $32 per device—$384 per device annually. ***Expanding the hotspot lending program would encourage more individuals to use broadband by increasing their access to service they could not afford on their own.*** We clarified in the report that it would cost approximately $1.6 million annually to deploy enough hotspots at libraries statewide so that there is one device for every 1,500 residents, which would be a reasonable ratio according to TSLA.
- As community anchor institutions, schools and libraries are vital resources that facilitate broadband use by making service available to students and community members who aren't able to afford it on their own. The federal E-Rate program provides subsidized broadband service to schools and libraries. The program's subsidies cover up to 90% of the cost of service. While every school and library in the state has internet access, not all have broadband quality service. ***The***

Department of Education and the Tennessee State Library and Archives should continue to work with schools and libraries to help them maximize the state's use of E-Rate funding to ensure that all schools and libraries have broadband. They should explore options to better educate them about the funds and the application process and to better assist them administratively in completing the applications.

- Broadband adoption programs typically offer some combination of digital literacy training, service discounts, and device subsidies. The Tech Goes Home program that began in Boston and has been implemented in Chattanooga and the Anytime Access for All and Connect Home initiatives in Nashville have combined digital literacy resources with service discounts and device subsidies to maximize their effectiveness. Adoption programs that target specific populations, such as the elderly and families with schoolchildren, also tend to be more successful. ***The state, through the coordinated efforts of its existing agencies, including the Department of Economic and Community Development, the Department of Education, and the regional development districts, and its existing local assistance resources, including the Municipal Technical Advisory Service and the County Technical Assistance Service, should encourage and assist local governments in establishing targeted broadband adoption programs that combine training and financial assistance.*** The cost per participant in programs like those in Nashville and Chattanooga ranges from $145 per participant for both of Nashville's programs to a two-year average of $330 per participant in Chattanooga's Tech Goes Home program. Although not everyone who completes these programs will adopt broadband, 91% of participants in Chattanooga's program subscribe to home broadband six months after completing the program, compared with only 64% before taking the program—Nashville does not collect before-and-after adoption data for its programs.

The report also makes several supporting recommendations to increase broadband availability in Tennessee:

- Reducing the costs of expanding networks by funding grants to providers is one option to help increase access to broadband throughout the state. The FCC is already offering grants totaling up to $210 million over seven years through the Connect America Fund phase II (CAF II) to three providers in Tennessee. Providers must use these grants to offer broadband of at least ten megabits per second download and one megabit per second upload to more than 93,000 homes and businesses. We have clarified in the report that the number of housing units in Tennessee census blocks where no provider reported offering

10/1 service as of December 2015 that won't receive coverage through CAF II will likely total between 114,000 and 160,000 units depending on the extent to which providers use funding in eligible census blocks where some 10/1 service is already reported. Several states have their own grant programs for expanding broadband coverage. The most successful of these, including Maine and Minnesota, use a competitive application process to choose projects to ensure that state funds maximize coverage in unserved and underserved areas. Tennessee Code Annotated, Section 7-59-315, already creates a broadband deployment fund for Tennessee, but no funds have ever been appropriated to it. ***Tennessee could use the broadband deployment fund to provide competitive grants to unserved or underserved areas not already being targeted by Connect America Fund grants.*** Expanding coverage of 10/1 to the remaining 114,000 to 160,000 housing units in census blocks where no provider reported offering at least 10/1 as of December 2015 that don't receive coverage through CAF II could cost between $125 million and $799 million. But some of these housing units may be served as a result of other Connect America Fund programs, leaving a smaller gap for any state grant program to fill. We have clarified in the report that the FCC is in the process of finalizing grants to other providers in Tennessee through the Connect America Fund alternative model and the Connect America Fund broadband loop support program (CAF BLS). The CAF alternative model could expand service to 14,000 housing units located in unserved blocks that aren't eligible for CAF II, while providers' build-out requirements through the CAF BLS program include an additional 6,000 locations. The FCC is also considering offering support to providers through an auction process that could expand coverage to another 8,000 housing units located in unserved blocks not eligible for CAF II, the CAF alternative model, or the CAF BLS program. After accounting for these programs, expanding coverage to the 86,000 to 132,000 housing units located in census blocks that still remain unserved could cost between $95 million and $661 million. We have also added a recommendation that ***Tennessee could use the broadband deployment fund to provide funding for programs and resources that encourage broadband adoption, though an additional authorization would likely be necessary to use the fund for these purposes.***

Cost to Expand Coverage to Housing Units in Unserved Census Blocks after CAF II, Alternative Model, Broadband Loop Support, and Auction Assuming All Units in CAF II Eligible Blocks Are Served

Number of Housing Units Remaining in Census Blocks Where No Provider Reported 10/1 as of December 2015	Housing Units	Cost to Expand Coverage		
		Range of ECD Cost Estimates		Southern Tier Wireless Cost Estimate for Fiber-to-the-Home ($5,000 per location)
		Fixed Wireless Min. Est. ($1,100 per location)	Fiber-to-the-Home Max. Est. ($3,840 per location)	
Before Accounting for CAF	193,881	$ 213,269,100	$ 744,503,040	$ 969,405,000
After CAF II (assumes all units in eligible blocks are served)	113,830	$ 125,213,000	$ 437,107,200	$ 569,150,000
After CAF Alternative Model	100,066	$ 110,072,600	$ 384,253,440	$ 500,330,000
After CAF BLS Build-Out Requirements	94,225	$ 103,647,500	$ 361,824,000	$ 471,125,000
After CAF Auction	86,176	$ 94,793,600	$ 330,915,840	$ 430,880,000

Cost to Expand Coverage to Housing Units in Unserved Census Blocks after CAF II, Alternative Model, Broadband Loop Support, and Auction Assuming 46,041 Units in CAF II Eligible Blocks Remain Unserved

Number of Housing Units Remaining in Census Blocks Where No Provider Reported 10/1 as of December 2015	Housing Units	Cost to Expand Coverage		
		Range of ECD Cost Estimates		Southern Tier Wireless Cost Estimate for Fiber-to-the-Home ($5,000 per location)
		Fixed Wireless Min. Est. ($1,100 per location)	Fiber-to-the-Home Max. Est. ($3,840 per location)	
Before Accounting for CAF	193,881	$ 213,269,100	$ 744,503,040	$ 969,405,000
After CAF II (assumes 46,041 units in eligible blocks remain unserved)	159,871	$ 175,858,100	$ 613,904,640	$ 799,355,000
After CAF Alternative Model	146,107	$ 160,717,700	$ 561,050,880	$ 730,535,000
After CAF BLS Build-Out Requirements	140,266	$ 154,292,600	$ 538,621,440	$ 701,330,000
After CAF Auction	132,217	$ 145,438,700	$ 507,713,280	$ 661,085,000

- Eliminating Tennessee's sales tax on equipment purchases could lower construction costs and thus encourage providers to build out their networks, and providers that are legacy telephone companies would benefit from having their telecommunications property assessed at the commercial rates for property tax purposes, like legacy cable television companies, rather than the higher utility rates. But eliminating the sales tax on broadband equipment would reduce state revenue by approximately $45.5 million per year and local revenue by approximately $16.3 million per year, according to the Tennessee Department of Revenue, and assessing legacy telephone companies at lower rates for property tax purposes would cost local governments more than $16 million per year, according to the Tennessee Comptroller of the Treasury. Moreover, neither approach is targeted to increase broadband investment in unserved and underserved areas. Instead, ***Tennessee could offer credits against franchise and excise taxes for broadband infrastructure investments, and target improvements to unserved and underserved areas by giving larger credits for investments in those unserved and underserved areas.*** Mississippi has a similar tax credit against franchise and excise taxes for broadband infrastructure investment that provides larger credits for investments in regions of the state that have lower levels of economic development. ***As is done with other tax credit programs such as the low-income housing tax credit, the state could cap the amount of credits available statewide per year and use competitive application processes to award credits.***
- Local governments already have several options for expanding broadband coverage in their jurisdictions by reducing regulatory burdens on providers seeking to expand their networks. Access to rights of way is governed by local permitting processes that can delay projects and increase costs, and zoning regulations effectively prevent wireless infrastructure from being built in certain communities. Controlling access to rights of way and regulating land use through zoning are vital local government functions, but some communities may find they can attract private investment to expand coverage by streamlining local regulatory processes. ***To assist communities that want to streamline local regulations, Tennessee could, like Indiana and Wisconsin, designate communities that adopt a checklist of permitting and zoning procedures as "broadband ready communities" to signal providers that they have removed regulatory barriers to broadband investment.***
- Municipalities with electric systems are authorized to provide broadband within their electric service areas by Tennessee Code Annotated, Section 7-52-601 et seq., and ten currently do so. Senate Bill 1134 by Senator Janice Bowling and House

Bill 1303 by Representative Kevin Brooks in the 109th General Assembly would have removed the territorial restriction on municipal broadband providers. But municipalities that build broadband infrastructure outside of their electric service areas and taxing jurisdictions put electric ratepayers and municipal taxpayers at risk in the event that they are unable to earn enough revenue from subscribers to make debt payments on bonds issued to expand their systems. Moreover, Morristown Utilities, which is one of two systems allowed to provide broadband outside its electric service area under state law (the other system, Covington, has since sold its network), has not chosen to expand service beyond a few communities because of the cost of doing so. Electric cooperatives—which are not currently authorized to provide broadband under Tennessee law—have helped expand broadband access in rural areas in other states by building their own networks and serving as retail internet service providers. Although existing telephone cooperatives are allowed to provide broadband in Tennessee and do in many rural areas, their service territories do not extend as far as those of the state's electric cooperatives. We have clarified in the report that ***Tennessee could simply authorize electric cooperatives to provide retail broadband service in their electric service areas, like the state's municipal electric systems, so long as electric ratepayer revenue is not used to subsidize the cost of service. Electric cooperatives would have flexibility either to build their own infrastructure, employ their own staff, and operate their own networks for providing broadband or to contract with existing providers—including for-profit providers, telephone cooperatives, and municipal electric systems—for some or all of these services. To the extent that electric cooperatives contract with municipal electric systems, however, the municipal electric systems would not be authorized to issue bonds backed by their ratepayers or municipal taxpayers to construct networks for providing broadband outside their electric service areas.***

- We have also clarified that ***an additional option would be to allow the state's electric cooperatives to enter more formal partnerships, rather than simply contracting for services, with existing providers—including for-profit providers, telephone cooperatives, and municipal electric systems—to provide broadband in the electric cooperatives' service areas. The state need not prescribe a specific framework for these partnerships and instead could allow electric cooperatives and any private sector partners the flexibility to structure partnerships to the advantage of all parties involved to the extent that the electric cooperatives' electric ratepayers are protected from subsidizing the cost of broadband service. Again, however, additional restrictions would be placed on municipal electric***

systems in these partnerships. Municipal electric systems would be forbidden from issuing bonds backed by their ratepayers or municipal taxpayers to construct networks for providing broadband outside their electric service areas, but they could use their existing staff and facilities to help operate the network. Tennessee Code Annotated, Section 7-59-316, already authorizes local governments, municipal utilities, and cooperatives, including electric cooperatives, to form joint ventures with existing providers to expand coverage but only within unserved areas that have been developed for residential use for five years, are outside of an existing cable franchise area, and which no other provider intends to serve. No one has set up a joint venture under this law according to TRA.

The report makes additional recommendations related to coordination and planning:

- Local planning and coordination with and among existing state agencies will be essential for increasing both adoption and access in Tennessee. Several states have created separate broadband offices to coordinate access and adoption strategies. While this approach can enable better coordination, it can create duplication, add complexity to decision making, and add to the cost of governing. Fortunately, this type of strategic coordination can be accomplished without having to create any new state agencies or offices. ***Tennessee could coordinate its broadband efforts using a standing working group made up of state and local officials, representatives of broadband providers, and representatives of the many non-profit organizations working to increase internet connectivity.*** An example of such a working group can be found with the state's Basic Education Program Review Committee, which meets periodically to help the administration and legislature set education funding priorities.
- ***The state could also include broadband as part of its annual infrastructure needs survey.*** By reporting broadband as a separate type within the transportation and other utilities category, the state can better calculate what the cost of meeting its broadband infrastructure needs are for the next five years.

Maximizing broadband's benefits to individuals and communities in Tennessee requires both encouraging adoption throughout the state and working with providers to increase availability in unserved and underserved areas. The cost per location of expanding broadband coverage in Tennessee could range from $1,100 per location for fixed wireless, according to the report accompanying ECD's broadband survey, to at least $5,000 per location for fiber-to-the-home, according to industry representatives.

As noted above, the cost per participant of broadband adoption programs like those in Nashville and Chattanooga ranges from $145 per participant for both of Nashville's programs to a two-year average of $330 per participant in Chattanooga's Tech Goes Home program.

We have clarified that simply expanding coverage to new locations does not guarantee that those who live or work there will adopt newly available broadband service and that not all those who complete broadband adoption programs ultimately adopt service. Cost per new subscriber is a better measure of how much it will cost to increase the number of Tennesseans who use broadband. Based on rates of broadband adoption reported by the FCC, the cost per new subscriber when simply expanding broadband coverage ranges from $2,391 to $10,870 per new subscriber for service of at least 10/1 and from $2,750 to $12,500 per new subscriber for service of at least 25/3. Based on Chattanooga's participant data, cost estimates per new subscriber for similar broadband adoption programs range from $193 per new subscriber for Nashville's Anytime Access for All program to $1,222 per new subscriber for Chattanooga's Tech Goes Home program. Estimates for these adoption programs vary widely in part because Chattanooga's program is open to individuals who already have home broadband while Nashville's Anytime Access for All program is not.

Cost to Increase Broadband Adoption: Expanding Coverage Alone Compared with Local Programs Targeted to Specific Populations

Cost	Expanding Broadband Coverage Alone		Local Programs for Encouraging Broadband Adoption that Target Specific Populations
	10/1 service	25/3 service	
Per New Location or Participant	$ 5,000*	$ 5,000**	$ 330***
Per New Subscriber	$ 10,870*	$ 12,500**	$ 1,222***
To Increase Broadband Adoption by 1% of Households Statewide	$ 272,234,348*	$ 313,069,500**	$ 30,611,240***

* Based on maximum cost per new location for fiber-to-the-home service using an estimate of $5,000 per location and 46% broadband adoption rate for those with access to 10/1 service in Tennessee reported in the FCC's 2015 Broadband Progress Report.

** Based on maximum cost per new location for fiber-to-the-home service using an estimate of $5,000 per location and 40% broadband adoption rate for those with access to 25/3 service in Tennessee reported in the FCC's 2016 Broadband Progress Report.

*** Based on two-year average cost per participant of Chattanooga's Tech Goes Home Program of $330 per participant and data from Chattanooga's program showing that 91% of participants subscribe to home broadband six months after completing the program, compared with only 64% before taking the program.

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Maximizing Broadband's Benefits: Encouraging Adoption and Facilitating the Expansion of Coverage

The US Telecom Association's assessment that broadband is a "critical enabler" that "supports economic growth through innovation and productivity" is shared by public and private sector alike. The Federal Communications Commission (FCC), in its 2010 National Broadband Plan, calls broadband

> a platform to create today's high-performance America—an America of universal opportunity and unceasing innovation, an America that can continue to lead the global economy, an America with world-leading, broadband-enabled health care, education, energy, job training, civic engagement, government performance and public safety.

Without broadband, according to the Institute for Local Self Reliance, a non-profit that advocates for community development, "businesses wither, students are at a disadvantage, economies become less competitive, and home values decline."

The Federal Communications Commission defines broadband as high-speed internet service with a capacity of at least 25 megabits per second download and three megabits per second upload that "enables users to originate and receive high-quality voice, data, graphics, and video." The good news is that 89% of Tennesseans already live in areas where providers report offering this broadband standard, though existing data do not say whether all Tennesseans in these areas have access to it. Access is still limited in many rural communities, and only 40% of households with access have chosen to adopt 25/3 broadband. Because of this, at TACIR's June 2015 meeting, Chairman Mark Norris requested the Commission study ways to improve broadband availability and adoption in Tennessee (appendixes A and B). ***The Commission's research has found that, fortunately, there are already several government and private initiatives to address both access and adoption. Tennessee should focus its efforts on supporting and coordinating these existing initiatives and on addressing any remaining coverage and adoption gaps. Any government response should focus on working with the private sector—both for-profit and non-profit—to fill the gaps in the manner least costly to taxpayers without expanding the role of government.***

Broadband is high-speed internet service that "enables users to originate and receive high-quality voice, data, graphics, and video," according to the FCC in its 2015 Broadband Progress Report.

Broadband is essential for economic development.

Broadband has become a near economic necessity in the 21st century. Although academics have at times had difficulty quantifying broadband's economic effects, recent research has found correlations between the expansion of broadband and local economic growth, especially for technology-intensive industries in sparsely populated areas. Studies also show that investments in broadband infrastructure correlate with increases in wages and employment and that broadband adoption correlates with increases in income in rural areas.

Broadband is increasingly important for attracting and retaining businesses, improving access to quality education and health care, and supporting a variety of other needs, especially in agriculture.

Communities without broadband have difficulty attracting and retaining businesses. More than one-third of the businesses that chose to participate in a recent Tennessee Department of Economic and Development (ECD) survey said broadband was essential for selecting their location, and more than half said it was essential for remaining in their current location. Broadband availability is a necessity in the site selection process for many businesses, according to economic development professionals. Almost 45% of development agencies that participated in ECD's survey reported that businesses either frequently or occasionally chose not to locate in their communities because of insufficient broadband.

Broadband also improves access to quality education and health care and is increasingly important to modern agriculture. Schoolwork is increasingly moving online, requiring students to have reliable, high-speed connections to complete assignments and conduct research. Broadband will only become more important as the state moves toward educational models that emphasize personalized instruction and learning. Access to video lectures and the ability to participate remotely in classroom discussions create educational opportunities for students whose schools cannot afford additional staff to teach advanced courses. Distance learning also benefits working adults and those who cannot travel by increasing access to Tennessee's colleges and universities as well as post-secondary programs in other states.

Patients and healthcare professionals both benefit from broadband's use. Video consultations improve access to specialists, particularly in communities located far from major hospitals, saving patients time and expense related to travel. Remote monitoring of patients can help doctors and nurses diagnose problems earlier, adjust medications, and prevent readmission to a hospital. Moreover, broadband facilitates the use of electronic health records, which help doctors and nurses efficiently access and manage patient information.

As the number of devices that are connected to the internet increases, the need for reliable high-speed connections will only grow. This is especially

true in agriculture, where increased connectivity allows farmers to collect vast amounts of information about the nutrient content of soil, water quality, and daily temperature changes that they can analyze to help maximize crop yields. Broadband enables the kind of data collection and analysis that has become necessary for farmers to remain competitive in global agriculture markets.

Internet speed is affected by capacity and by signal lag.

While internet service is widely available in Tennessee, it is not always available at speeds high enough to qualify as broadband. Speed varies by capacity—the amount of data measured in binary units called bits that users can send or receive per second. Every image, every piece of text, audio, or video sent or received gets translated into strings of bits—ones and zeroes—so that it can be transmitted over the internet. While simple emails and text-only webpages may be made up of several thousand bits, feature length movies and complex radiological images may be several billion.[1] An internet connection's capacity affects the amount of time it takes to send or receive files of varying sizes or access websites, and it affects the quality of tasks that involve streaming data continuously, such as watching videos or teleconferencing.

Ten megabits per second download and one megabit per second upload is the current minimum necessary for broadband capability, but some individual users as well as large industries, hospitals, schools and universities, and libraries require more to meet their needs.

While the FCC's definition is 25/3, the minimum capacity necessary for internet access to provide broadband capability is ten megabits per second download and one megabit per second upload.[2] Ten megabits per second is enough to access emails or websites, make voice or video calls, download moderately sized files—such as photo albums containing approximately 20 pictures—in less than one minute, or watch high-definition videos. Most residential users do not upload large files to the internet. The FCC even uses 10/1 as its minimum standard for several of its subsidy programs despite adopting 25/3 as its definition of broadband.

Although communities with access to 10/1 internet service do have broadband, they are underserved. Businesses typically upload more information than residential users and require higher capacity upload speeds as a result. While ten megabits per second will support most individual tasks residential users perform, it is not enough for individuals who perform multiple high-capacity tasks at once or households where more than one person uses the internet simultaneously. The 25/3 standard for broadband that the FCC adopted in January 2015 is a better measure of what communities will need to support residential and business users.

[1] Although discussed in bits here for purposes of continuity, file sizes are typically displayed in bytes; there are eight bits in every byte.
[2] A megabit is one million bits.

However, large industries, hospitals, schools and universities, and libraries can require connections of at least one gigabit per second download and upload both because of the very large files, such as radiological images, that they transmit and because of the number of users who share their connections.[3]

In addition to capacity, speed is affected by the amount of time it takes signals to travel from one end of a connection to another—from one user's device to another.[4] The lag between when a signal is sent and received negatively affects tasks that require real-time communication, including those like voice calling that only use small amounts of data, and can render an internet connection insufficient for these uses even if it has enough capacity to support them. Lag times of even one-fifth of a second can be unacceptable for voice calls.

The various wired and wireless infrastructures used to provide broadband have different physical properties and technical specifications that affect performance, but they all support high-speed internet; no one technology is currently able to meet all users' needs.

No single broadband delivery method meets all users' needs.

Broadband is provided over local, regional, national, and international networks made up of a variety of infrastructures, including fiber-optic cable, wireless transmitters and receivers, and the same copper wire and coaxial cable originally deployed for telephone and cable television service respectively. Each of these infrastructures has different physical properties and technical specifications that affect performance, but they are all capable of supporting high-speed internet service.

Depending on users' needs, the differences between broadband infrastructures mean the various methods for delivering service are not always interchangeable. Industries and other large users may require multi-gigabit per second capacities that at present can only be provided through wired connections, though the next generation of wireless broadband—so-called 5G wireless—has approached four gigabits per second in testing. Conversely, in agriculture the sensors that transmit information about soil conditions and temperature as well as the guidance systems that help equipment such as tractors and combines follow precise routes through fields require wireless connections.

For residential and business users, satellite internet and mobile wireless are not comparable substitutes for wireline and fixed wireless broadband at present. While satellite internet service can provide users with connections of at least 10/1, it suffers from lag times that can degrade voice calls and other real-time communications because of the distance signals must travel to and from the satellite itself. Satellite internet plans also limit

[3] A gigabit is one billion bits (one thousand megabits).
[4] This lag between when a signal is sent and received is commonly referred to as latency.

subscribers to less data than similarly priced plans offered by wireline and fixed wireless providers. Users that reach these caps either have to purchase more data or have the capacity of their connection reduced below broadband quality for the rest of the month.

Mobile wireless connections provide users with similar capacity and lag times to most wireline and fixed wireless services, but mobile service plans, like satellite plans, currently include significantly smaller data caps than similarly priced plans offered by wireline or fixed wireless providers. These caps make it difficult to treat mobile wireless as a comparable service to fixed wireless and wireline broadband for residential and business users.

Access to broadband is improving in Tennessee, but coverage is still limited in rural areas.

Approximately 89% of Tennesseans live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 25/3, according to data collected by the FCC in December 2015, an increase of two percent from 2014 and seven percent from 2013. More than 93% live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 10/1 as of December 2015, an increase of four percent from 2013. This represents the maximum extent of wireline and fixed wireless broadband coverage. The data do not say whether everyone in these census blocks has access to service at the reported capacities. According to the FCC, "providers file lists of census blocks in which they can or do offer service to at least one location," but "a provider that reports deployment of a particular technology and bandwidth in a census block may not necessarily offer that service everywhere in the block."

Rural areas are still less likely to have access than urban areas. Ninety-eight percent of Tennesseans in urban areas live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 25/3 in December 2014, compared with only 66% of those in rural areas. Overall, Tennessee ranked 29th in the nation for coverage of at least 25/3, according to the FCC's 2016 Broadband Progress Report, and 5th among southeastern states including the eight states that it borders and South Carolina, Louisiana, and Florida.

The cost per location of expanding broadband coverage in Tennessee could range from $1,100 per location for fixed wireless, according to a report accompanying the results of ECD's broadband survey, to at least $5,000 per location for fiber-to-the-home, according to industry representatives. But simply expanding coverage to new locations does not guarantee that those who live or work there will adopt newly available broadband service.

Overall, Tennessee ranks 29th in the nation for broadband coverage and 19th for broadband adoption, according to the FCC in its 2016 Broadband Progress Report.

Cost per new subscriber is a better measure of how much it will cost to increase the number of Tennesseans who use broadband. Based on rates of broadband adoption reported by the FCC, the cost per new subscriber when simply expanding broadband coverage ranges from $2,391 to $10,870 per new subscriber for service of at least 10/1 and from $2,750 to $12,500 per new subscriber for service of at least 25/3 (see table 1).

Less than half of Tennesseans with access to broadband subscribe to the service, though adoption rates continue to increase.

Only 40% of households located in census blocks where at least one provider reported offering at least 25/3 broadband subscribed to the service, according to the FCC's 2016 Broadband Progress Report, an increase of three percent from the year before. It is possible that the state's adoption rate is higher than reported by the FCC because, as noted above, the data do not say whether everyone in these blocks has access to service. Tennessee is tied for 19th out of 45 states for which the FCC reports adoption data but is second among the twelve southeastern states.

Barriers to broadband adoption include perceived lack of relevance, lack of skill, and the cost of service and devices. "These barriers are cross-cutting, and many individuals cite more than one barrier as a reason for non-adoption," according to the National Telecommunications and Information Administration. "Adoption programs need to meet people where they are, encourage them, and show them how they can safely use the internet to improve their lives."

Whether individuals adopt broadband service is a function of value and affordability. Perceived lack of relevance or lack of skill both affect whether individuals value broadband enough to use and subscribe to a service. More than half of respondents in a 2013 Pew survey cited lack of relevance or skill as their primary reason for not using the internet. In addition to value, both the cost of service and the cost of devices are also often cited as reasons for not using or subscribing to broadband especially for those with lower household incomes. Eighty-one percent of respondents with incomes below $30,000 per year who chose to participate in ECD's survey said that affordability was a major concern when selecting an internet service provider.

Tennessee already has several public and private resources available for improving digital literacy and reducing the cost of devices and service. Libraries and schools provide access to training as well as service and devices for those who cannot afford their own. Discount programs for broadband service are also available from internet providers, and the federal government expanded its telephone service discount program for low-income populations to include broadband in December 2016.

Libraries

Tennessee's local library system is an existing resource that is positioned to help residents improve their digital literacy skills and learn about the ways they can benefit from broadband. The Tennessee State Library and Archives

(TSLA) encourages the state's local libraries to offer digital literacy training regularly to patrons. TSLA has adopted technology services guidelines that call for all libraries serving at least 5,000 patrons to offer meeting space and devices to community organizations for digital literacy training. Libraries are also encouraged to provide digital literacy training several times a year depending on size, ranging for once per quarter for smaller libraries to twice per month for larger libraries. Approximately 75% of libraries serving at least 5,000 patrons currently meet these technology services guidelines, according to TSLA. ***Increasing funding so that all libraries meet TSLA's guidelines would improve access to digital literacy resources throughout the state and could assist communities that want to implement programs for encouraging broadband adoption.*** Ensuring that all libraries meet TSLA's guidelines would cost approximately $144,640 per year, according to TSLA.

Further, 18 libraries throughout the state are addressing the affordability gap in their communities by lending hotspot devices that allow patrons to access wireless broadband. These programs provide patrons with service when they most need it, such as working on a research project for school or after they have already exceeded data caps for their own mobile wireless service. Although the devices initially cost approximately $130 each, providers are now offering them to libraries at no cost. Broadband service for the devices costs approximately $32 per device per month—$384 per device annually—and can be shut off remotely if devices are not returned. ***Expanding the hotspot lending program would encourage more individuals to use broadband by increasing their access to service they could not afford on their own.*** It would cost approximately $1.6 million annually to deploy enough hotspots at libraries statewide so that there is one device for every 1,500 residents, which would be a reasonable ratio according to TSLA.

Community anchor institutions, including libraries and schools, can play important roles in facilitating adoption initiatives by providing digital literacy training and by addressing the affordability gaps in their communities by providing access to devices and broadband service.

Schools

Local schools are another resource for improving digital literacy skills and access to devices. The Tennessee Department of Education is considering a partnership with Microsoft for digital literacy resources that will be free for every high school student in the state. These resources would include instruction on using the Microsoft Office suite of products as well as developing and writing computer code. As instruction and assignments move online, the need for every student in a classroom to have a broadband enabled device also increases. But purchasing new or replacing existing devices has traditionally been cost prohibitive for most schools. To overcome this barrier, the Tennessee Department of Education is developing a purchasing model that will allow schools to lease devices for $5 per student per month; the devices will be replaced every three years. This will allow schools to obtain more devices and make those devices available to be taken home by students.

Discount Programs

Several broadband discount programs are available to low-income households. Many broadband providers already offer their own discount programs. Eligibility for these programs varies by provider, but participants typically receive broadband that meets the minimum 10/1 requirement for approximately $10 per month. Some providers offer digital literacy training and device discounts to program participants as well. The FCC recently expanded its Lifeline program from mobile and wireline telephone service to include broadband as of December 2016. Participants are given a $9.25 per month service discount. Although the federal government does not offer device discounts under the Lifeline program, some providers have offered free devices to participants when the program applied to telephone service alone. It is too early to tell whether providers will offer free or discounted broadband devices to Lifeline participants now that the program has been expanded to include broadband service.

Both provider-led discount programs and the federal Lifeline program are available to reduce the cost of broadband to low-income households. Similarly, the federal E-Rate program reduces the cost of broadband to schools and libraries.

The federal E-Rate program provides subsidized broadband service to schools and libraries. The program's subsidies cover up to 90% of the cost of service. While every school and library in the state has internet access, not all have broadband quality service. ***The Department of Education and the Tennessee State Library and Archives should continue to work with schools and libraries to help them maximize the state's use of E-Rate funding to ensure that all schools and libraries have broadband. They should explore options to better educate them about the funds and the application process and to better assist them administratively in completing the applications.*** As community anchor institutions, schools and libraries are vital resources that facilitate broadband use by making service available to students and community members who aren't able to afford it on their own.

No studies have shown conclusively that any of the three approaches—training, service discounts, or device subsidies—are more effective at increasing adoption than the others. Evidence suggests that it is more important to develop programs that target specific populations, such as the elderly and families with schoolchildren. Several successful programs, including the Tech Goes Home program that began in Boston and has been implemented in Chattanooga and the Anytime Access for All and Connect Home initiatives in Nashville, combine digital literacy resources with service discounts and device subsidies to maximize their effectiveness. The Tech Goes Home, Anytime Access for All, and Connect Home programs condition service discounts and device subsidies on completion of a set amount of digital literacy training. The cost per participant for these programs ranges from $145 per participant for both of Nashville's programs to a two-year average of $330 per participant in Chattanooga's Tech Goes Home program. Although not everyone who completes these programs will adopt broadband, 91% of participants in Chattanooga's

program subscribe to home broadband six months after completing the program, compared with only 64% before taking the program—Nashville does not collect before-and-after adoption data for its programs. Based on Chattanooga's participant data, cost estimates per new subscriber for these programs range from $193 per new subscriber for Nashville's Anytime Access for All program to $1,222 per new subscriber for Chattanooga's Tech Goes Home program (see table 1). These estimates vary widely in part because Chattanooga's program is open to individuals who already have home broadband while Nashville's Anytime Access for All program is not. ***The state, through the coordinated efforts of its existing agencies, including the Department of Economic and Community Development, the Department of Education, and the regional development districts, and its existing local assistance resources, including the Municipal Technical Advisory Service and the County Technical Assistance Service, should encourage and assist local governments in establishing targeted broadband adoption programs that combine training and financial assistance.***

Table 1. Cost to Increase Broadband Adoption: Expanding Coverage Alone Compared with Local Programs Targeted to Specific Populations

Cost	Expanding Broadband Coverage Alone		Local Programs for Encouraging Broadband Adoption that Target Specific Populations
	10/1 service	25/3 service	
Per New Location or Participant	$ 5,000*	$ 5,000**	$ 330***
Per New Subscriber	$ 10,870*	$ 12,500**	$ 1,222***
To Increase Broadband Adoption by 1% of Households Statewide	$ 272,234,348*	$ 313,069,500**	$ 30,611,240***

* Based on maximum cost per new subscriber for fiber-to-the-home service using an estimate of $5,000 per location and 46% broadband adoption rate for those with access to 10/1 service in Tennessee reported in the FCC's 2015 Broadband Progress Report.

** Based on maximum cost per new subscriber for fiber-to-the-home service using an estimate of $5,000 per location and 40% broadband adoption rate for those with access to 25/3 service in Tennessee reported in the FCC's 2016 Broadband Progress Report.

*** Based on two-year average cost per participant of Chattanooga's Tech Goes Home Program of $330 per participant and data from Chattanooga's program showing that 91% of participants subscribe to home broadband six months after completing the program, compared with only 64% before taking the program.

Source: TACIR staff calculations based on 2010 Census; Southern Tier Wireless 2016; Federal Communications Commission 2015d; Federal Communications Commission 2016h; and telephone interview with Kelly McCarthy, program director, Tech Goes Home Chattanooga, January 4, 2017.

Programs for improving digital literacy and reducing the cost of both broadband service and devices can be effective ways to increase rates

of broadband adoption. But coverage gaps still remain. Maximizing broadband's benefits to individuals and communities in Tennessee requires both encouraging adoption throughout the state and working with providers to increase availability in unserved and underserved areas.

Filling existing coverage gaps will help ensure that all Tennesseans are able to take advantage of broadband's benefits.

In many unserved and underserved areas, the cost of providing service is greater than the revenue that can be expected from subscribers. Low population densities make it particularly difficult for providers to cover their costs in many of these areas. While increasing adoption rates can help providers justify investments to expand coverage by increasing their expected revenue, encouraging adoption alone is unlikely to solve the state's access problems. Some approaches to enable expansion of coverage include providing grants, reducing providers' tax burdens, reducing local regulation, encouraging public-private partnerships, and coordinating the efforts of federal, state, and local governments both with each other and with businesses and non-profit organizations.

In a 2014 report on policies for expanding broadband coverage in unserved and underserved areas, the US Government Accountability Office says that "remote areas generally have high costs to deploy broadband due to the expense of deploying technologies over long distances and potentially difficult terrain to often relatively few potential subscribers. For these reasons, stakeholders told us that being able to cover costs with potential revenues and thus make a return on investment is a key issue to deploying broadband in unserved and underserved areas."

Grants

Reducing the costs of expanding networks by funding grants to providers is one option to help increase access to broadband throughout the state. The FCC is already offering grants totaling up to $210 million over seven years through the Connect America Fund phase II (CAF II) to three providers in Tennessee. Providers must use these grants to offer broadband of at least ten megabits per second download and one megabit per second upload to more than 93,000 homes and businesses. There will likely be between 114,000 and 160,000 housing units[5] remaining in census blocks in Tennessee where no provider reported 10/1 service as of December 2015 that won't receive coverage through the CAF II program depending on the extent to which providers use funding in census blocks where some 10/1 service is already reported. This range exists in part because the FCC determined which census blocks were eligible for the CAF II program based on 2013 coverage data, and some blocks still eligible for funding have had 10/1 service expanded to them in the interim. The FCC is in the process of finalizing grants to other providers in Tennessee through the Connect America Fund alternative model and the Connect America Fund broadband loop support program (CAF BLS). The CAF alternative model

[5] The CAF II grants can be used to provide service to homes or businesses; however, for the following calculations TACIR staff rely on the number of housing units in each census block alone because the number of businesses in each block is not reported in the 2010 Census.

could expand service to 14,000 housing units located in unserved blocks that aren't eligible for CAF II, while providers' build-out requirements through the CAF BLS program include an additional 6,000 locations. The FCC is also considering offering support to providers through an auction process that could expand coverage to another 8,000 housing units located in unserved blocks not eligible for CAF II, the CAF alternative model, or the CAF BLS program. After accounting for each of these federal programs, there could be between 86,000 and 132,000 housing units in the remaining census blocks in Tennessee where no provider reported 10/1 service as of December 2015.

Several states have their own grant programs for expanding broadband coverage. The most successful of these, including Maine and Minnesota, use a competitive application process to choose projects to ensure that state funds maximize coverage in unserved and underserved areas. Maine's program has resulted in almost 39,000 homes and businesses getting access to broadband since 2007, and Minnesota's has funded projects for approximately 6,000 homes and businesses in 2015. Maine and Minnesota also demonstrate two different ways to fund broadband grant programs. Maine funds its program through a tax on telephone service, while Minnesota relies on annual appropriations from the state legislature.

After accounting for coverage expansions that could result from current and proposed federal Connect America Fund grant programs, expanding broadband to the remaining 86,000 to 132,000 housing units located in census blocks where no provider reported offering service of at least 10/1 as of December 2015 could cost between $95 million and $661 million.

Tennessee Code Annotated, Section 7-59-315, already creates a broadband deployment fund for Tennessee, but no funds have ever been appropriated to it. The Tennessee Regulatory Authority (TRA) is responsible for administering the fund. ***Tennessee could use the broadband deployment fund to provide competitive grants to unserved or underserved areas not already being targeted by Connect America Fund grants.*** Expanding coverage of 10/1 to the remaining 114,000 to 160,000 housing units in census blocks that don't receive coverage through CAF II could cost between $125 million and $799 million. But some of these housing units may be served as a result of other Connect America Fund programs, leaving a smaller gap for any state grant program to fill. Expanding coverage to the 86,000 to 132,000 housing units located in census blocks that still remain unserved after accounting for the CAF alternative model, CAF BLS program, and CAF auction could cost between $95 million and $661 million. ***Tennessee could also use the broadband deployment fund to provide funding for programs and resources that encourage broadband adoption, though an additional authorization would likely be necessary to use the fund for these purposes.***

Reducing Tax Burdens

Eliminating Tennessee's sales tax on equipment purchases could lower construction costs and thus encourage providers to build out their networks, according to representatives who spoke at TACIR's May 2016

meeting. Providers that are legacy telephone companies would also benefit from having their telecommunications property assessed at the commercial rates for property tax purposes, like legacy cable television companies, rather than at the higher utility rates. Twenty-two states and the District of Columbia already don't tax equipment purchases, and Tennessee is one of only eight states that assess legacy telephone companies at higher rates for property tax purposes, although these companies are partially reimbursed by the state's ad valorem tax reduction fund. But eliminating the sales tax on broadband equipment would reduce state revenue by approximately $45.5 million per year and local revenue by approximately $16.3 million per year, according to the Tennessee Department of Revenue, and assessing legacy telephone companies at lower rates for property tax purposes would cost local governments more than $16 million per year, according to the Tennessee Comptroller of the Treasury. Moreover, neither approach is targeted to increase broadband investment in unserved and underserved areas.

Several other states encourage broadband deployment by offering tax credits to providers. Mississippi and Georgia offer larger credits to providers that expand coverage in areas with lower levels of economic development.

Instead, ***Tennessee could offer credits against franchise and excise taxes for broadband infrastructure investments, and target improvements to unserved and underserved areas by giving larger credits for investments in those unserved and underserved areas.*** Mississippi has a similar tax credit against franchise and excise taxes for broadband infrastructure investment that provides larger credits for investments in regions of the state that have lower levels of economic development, while Georgia offers credits against corporate income taxes to providers that expand their networks, also targeting larger credits to investments in less developed areas. ***As is done with other tax credit programs such as the low-income housing tax credit, the state could cap the amount of credits available statewide per year and use competitive application processes to award credits.***

Lowering Local Regulatory Hurdles

Local governments already have several options for expanding broadband coverage in their jurisdictions by reducing regulatory burdens on providers seeking to expand their networks. Access to rights of way is governed by local permitting processes that can delay projects and increase costs, and zoning regulations effectively prevent wireless infrastructure from being built in certain communities. Controlling access to rights of way and regulating land use through zoning are vital local government functions, but some communities may find they can attract private investment to expand coverage by streamlining local regulatory processes. ***To assist communities that want to streamline local regulations, Tennessee could, like Indiana and Wisconsin, designate communities that adopt a checklist of permitting and zoning procedures as "broadband ready communities" to signal providers that they have removed regulatory barriers to broadband investment.***

Pole attachment fees also affect the cost to providers of expanding service. The new formula for calculating these fees adopted by the Tennessee Valley Authority (TVA) in February 2016 may nearly double the current median fee charged by the utilities and cooperatives that TVA serves and will apply to most of the utility poles in Tennessee, though not all of the attachments on them. The formula will apply only to new or renewal pole attachment contracts that don't meet TVA's forthcoming definition of a joint use or reciprocal agreement. Attachments on poles owned by entities other than the utilities and cooperatives TVA serves are also not subject to the formula. TVA's formula results in higher pole attachment fees than would be charged under FCC guidelines for poles owned by for-profit utilities. The difference can be several orders of magnitude and results because TVA and the FCC have divergent goals when regulating pole attachments. TVA's statutory mandate is to provide its service area with electricity at rates as low as feasible. In contrast, the FCC's guidelines are based on its goal of "promoting consistent, cross-industry attachment rates that encourage deployment and adoption of broadband internet access services." Tennessee could attempt to legislate the pole attachment fees charged by municipal utilities and electric cooperatives in the state. But because of TVA's authority to regulate the utilities and cooperatives it serves, Tennessee likely lacks authority to override TVA's formula, according to a 2014 opinion by the state's attorney general.

The opinion says that

> [r]egulation by the State of the rates, terms, and conditions of pole attachments of the TVA's distributors is not, currently, clearly preempted by the TVA Act, provided that State regulation does not affect either those distributors' rates for electric power or their ability to comply with their agreements with the TVA. *If the TVA were to assert its discretionary control over the rates and revenues of its distributors in a manner that directly affected pole attachments, regulation by the State would likely be preempted.* (emphasis added)

Tennessee is one of almost 30 states that place at least some restrictions on municipalities that provide broadband. Common restrictions include territorial limitations, prohibitions against subsidizing the cost of service, and requirements that municipalities produce cost-benefit analyses as well as hold public hearings, referenda, or both before providing service. Texas prohibits municipalities from providing broadband, while Nebraska, Nevada, Utah, and Washington only authorize municipalities to act as wholesalers.

Municipal Utilities and Electric Cooperatives

Municipalities with electric systems are authorized to provide broadband within their electric service areas by Tennessee Code Annotated, Section 7-52-601 et seq., and ten currently do so. Senate Bill 1134 by Senator Janice Bowling and House Bill 1303 by Representative Kevin Brooks in the 109th General Assembly would have removed the territorial restriction on municipal broadband providers. But municipalities that build broadband infrastructure outside of their electric service areas and taxing jurisdictions put electric ratepayers and municipal taxpayers at risk in the event that

they are unable to earn enough revenue from subscribers to make debt payments on bonds issued to expand their systems. While utilities can justify bonds for providing broadband inside their electric service areas at least in part based on the benefits to electric ratepayers that can result from the construction of communications networks that support management and operation of the electric grid, this dual justification doesn't exist for utilities providing broadband outside their electric service areas. Moreover, Morristown Utilities, which is one of two systems allowed to provide broadband outside its electric service area under state law, has not chosen to expand service beyond a few communities because of the cost of doing so. The other system, Covington, has since sold its network.

Of the 56 municipal electric systems in Tennessee, 10 currently provide broadband, while two others built broadband networks in the past but have since sold them.

Electric cooperatives have helped expand broadband access in rural areas in other states by building their own networks and serving as retail internet service providers. Many of the same resources for constructing broadband infrastructure that exist for municipal utilities, for-profit providers, and especially telephone cooperatives are also available to electric cooperatives. For example, some though not all of the electric cooperatives that have either built or are in the process of building broadband networks have taken advantage of federal grants, and like other providers, electric cooperatives have access to loans through programs managed by the US Department of Agriculture's Rural Utilities Service. The National Rural Utilities Cooperative Finance Corporation—a non-profit financing cooperative created in 1969 to raise funds for electric cooperatives—has also provided loans to help finance some electric cooperatives' broadband projects.

But electric cooperatives are not currently authorized to provide retail broadband service under Tennessee law. Although existing telephone cooperatives are allowed to provide broadband and do in many rural areas, their service territories do not extend as far as those of the state's electric cooperatives. ***Tennessee could simply authorize electric cooperatives to provide retail broadband service in their electric service areas, like the state's municipal electric systems, so long as electric ratepayer revenue is not used to subsidize the cost of service. Electric cooperatives would have flexibility either to build their own infrastructure, employ their own staff, and operate their own networks for providing broadband or to contract with existing providers—including for-profit providers, telephone cooperatives, and municipal electric systems—for some or all of these services. To the extent that electric cooperatives contract with municipal electric systems, however, the municipal electric systems would not be authorized to issue bonds backed by their ratepayers or municipal taxpayers to construct networks for providing broadband outside their electric service areas.***

Municipal electric systems may need additional authorization to fulfill contracts for the component services involved in providing broadband to the extent that selling these services to electric cooperatives or other

providers involves equipment, facilities, or on-site work outside municipal electric systems' service areas. Examples of these component services include use of equipment and staff to operate and manage providers' local networks as well as connections to so-called middle-mile and backbone networks that give providers' local networks access to the wider internet. Representatives for municipal providers say they are authorized to operate or lease equipment and facilities located within their electric service areas and to provide other support services under Tennessee Code Annotated, Section 7-52-601, to assist other entities that provide broadband outside their electric service areas, and at least one municipal electric system is reportedly doing so. Municipal electric systems are also authorized to provide telecommunications services outside of their electric service areas under Tennessee Code Annotated, Section 7-52-401, but internet service is not explicitly included in the definition of telecommunications in state law. According to a 2014 opinion of the Tennessee Attorney General on whether electric cooperatives are authorized to provide retail broadband service through their current authorization to provide telecommunications services,

> [t]he term "telecommunications" does not inherently include Internet service. . . . Unless the term "telecommunications" is expressly defined to include Internet services, therefore, that term cannot be construed as including such services.

Broadband Partnerships

An additional option would be to allow the state's electric cooperatives to enter more formal partnerships, rather than simply contracting for services, with existing providers—including for-profit providers, telephone cooperatives, and municipal electric systems—to provide broadband in the electric cooperatives' service areas. The state need not prescribe a specific framework for these partnerships and instead could allow electric cooperatives and any private sector partners the flexibility to structure partnerships to the advantage of all parties involved to the extent that the electric cooperatives' electric ratepayers are protected from subsidizing the cost of broadband service. Again, however, additional restrictions would be placed on municipal electric systems in these partnerships. Municipal electric systems would be forbidden from issuing bonds backed by their ratepayers or municipal taxpayers to construct networks for providing broadband outside their electric service areas, but they could use their existing staff and facilities to help operate the network. Partnerships are not without risk. Memphis Networx, a partnership between the city's electric system and private investors to build a network for providing wholesale broadband service, failed because it could not sign up retail providers to offer service over its network. A wholesale network in Provo, Utah, also failed because the city's private sector retail partner did not

Electric cooperatives are private, non-profit corporations that provide electric service in many communities in Tennessee and across the nation. In other states—including Alabama, Arkansas, Colorado, Georgia, Indiana, Michigan, Missouri, New Mexico, North Carolina, Oklahoma, Oregon, and Virginia—they have helped expand broadband access in rural areas by building their own networks and serving as retail internet service providers. But electric cooperatives are not currently authorized to provide broadband individually under Tennessee law.

generate enough revenue to make debt payments. Similarly, a partnership involving the town of Monticello, Minnesota, failed because it could not compete against an incumbent provider that was able to reduce its rates below the cost of providing service.

Tennessee Code Annotated, Section 7-59-316, already authorizes local governments, municipal utilities, and cooperatives, including electric cooperatives, to form joint ventures with existing providers to expand coverage but only within unserved areas that have been developed for residential use for five years, are outside of an existing cable franchise area, and which no other provider intends to serve. No one has set up a joint venture under this law, according to TRA.

"Public-private partnerships can effectively address any aspect of the broadband connectivity paradigm," according to New York Law School professors Charles Davidson and Michael Santorelli. "Such partnerships are critical because they seek to 'apply the resources of the private sector in meeting the needs of the public.'"

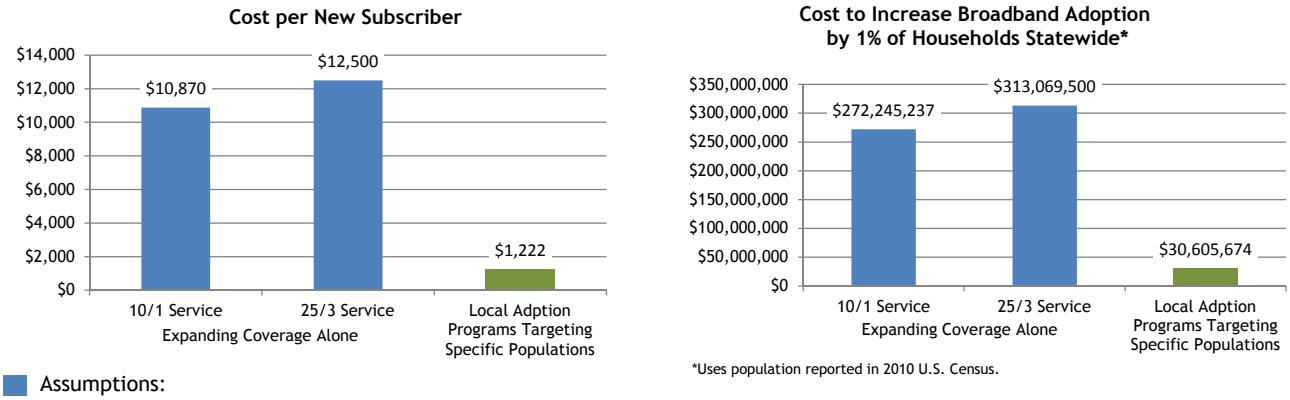
Strategic Cooperation

Planning and coordination with and among existing state and local agencies will be essential for increasing both adoption and access in Tennessee. Local governments are best situated to determine their communities' needs, especially for adoption programs. Much of this planning and coordination could take place within existing collaborative organizations, including the state's development districts and the Joint Economic and Community Development Boards authorized under Public Chapter 1101. Connected Tennessee—the state's affiliate of the non-profit Connected Nation that collected information on broadband availability, adoption, and use—also provided assistance to communities in developing local adoption and access plans before its funding ran out. Community plans can determine target populations for adoption programs and the most appropriate strategies for expanding coverage.

Several states have created separate broadband offices to coordinate access and adoption strategies. While this approach can enable better coordination, it can create duplication, add complexity to decision making, and add to the cost of governing. Fortunately, this type of strategic coordination can be accomplished without having to create any new state agencies or offices. ***Tennessee could coordinate its broadband efforts using a standing working group made up of state and local officials, representatives of broadband providers, and representatives of the many non-profit organizations working to increase internet connectivity.*** An example of such a working group can be found with the state's Basic Education Program Review Committee, which meets periodically to help the administration and legislature set education funding priorities.

The state could also include broadband as part of its annual infrastructure needs survey. By reporting broadband as a separate type within the transportation and other utilities category, the state can better calculate what the cost of meeting its broadband infrastructure needs are for the next five years.

Cost Effectiveness of Expanding Coverage Compared with Local Broadband Adoption Programs Targeted to Specific Populations



*Uses population reported in 2010 U.S. Census.

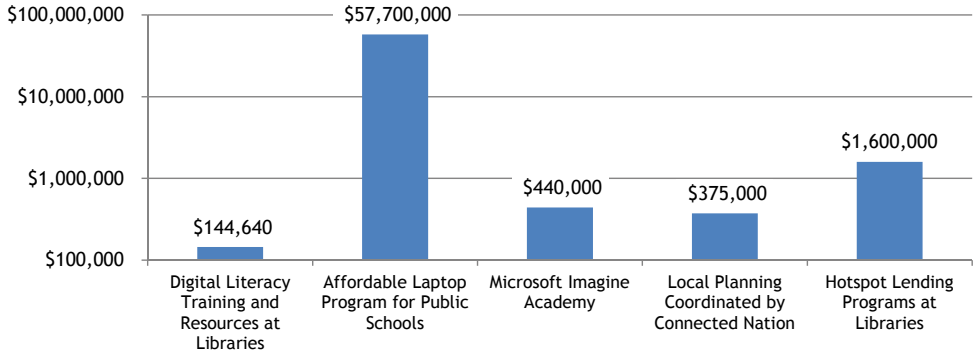
Assumptions:

- Cost per location is $5,000 for fiber-to-the-home
- 46% with access subscribe to service of at least 10/1
- 40% with access subscribe to service of at least 25/3

Assumptions:

- Cost per participant is $330
- For programs open to participants who already have broadband, 91% subscribe to broadband after the program compared with 64% before starting the program

Annual Cost Comparison of Other Programs for Encouraging Broadband Adoption



Digital Literacy Training and Resources at Libraries

- Cost: $144,640 per year to ensure that all libraries meet voluntary guidelines adopted by Tennessee State Library and Archives

Affordable Laptop Program for Public Schools

- Cost: $5 per student per month and $57.7 million per year to provide devices to every pubic school student in state
- Assumptions: Uses 2015-2016 Average Daily Membership (ADMs) for total number of public school students

Microsoft Imagine Academy

- Cost: $440,000 per year for a statewide license

Local Planning Coordinated by Connected Nation

- Cost: $375,000 annually to assist approximately 16 communities per year
- Assumptions: Uses annual budget and number of communities assisted per year from Connected Nation's affiliate in Michigan

Hotspot Lending Programs at Libraries

- Cost: $1.6 million per year to deploy enough devices in libraries statewide to achieve ratio of 1 device per 1,500 residents
- Assumption: Uses population reported in 2010 Census and assumes cost of $32 per device per month for broadband service

Local Programs Targeting Specific Populations

Anytime Access for All (Nashville)

Overview: Participants who complete 3 hours of digital literacy training provided by Nashville Public Library, Metro-Nashville Public Schools, or non-profit partners receive option to purchase broadband-enabled device for $25 and discounted broadband service through existing programs of broadband providers.

Eligibility: Families with children attending public schools where program is offered who do not currently have computers or fixed internet service at home.

Cost:

- **$145 per participating family**
- **$193 per new broadband subscriber**

Additional Information:

- Data on effectiveness not available. Similar program in Chattanooga has resulted in 91% of participants subscribing to broadband 6 months after the program, but it was not restricted to those without home internet service.
- Vanderbilt University's donation of used computers helps reduce overall cost of program related to obtaining devices for participants.
- Cost per new subscriber also lower than other programs because eligibility is restricted to those who do not currently subscribe to home internet service.
- Program does not pay for participants' internet service.

Tech Goes Home Chattanooga

Overview: Participants who complete 15 hours of digital literacy training provided by schools, libraries, churches, community centers, or other non-profit partners receive option to purchase broadband-enabled device for $50, if eligible, and assistance signing-up for discounted broadband service through existing programs of broadband providers. Tech Goes Home uses a "train-the-trainer model" where Tech Goes Home staff train staff of partner organizations (schools, libraries, etc.) to provide digital literacy training to program participants.

Eligibility: Varies for each of the program's components.

- Partner organizations determine eligibility for training.
- Broadband providers determine eligibility for service discounts.
- Device discounts are only available to participants who have incomes below $30,000 per year with exceptions for large families, have a disability or have a family member with a disability, have been unemployed or underemployed for an extended period, don't have a desktop or laptop computer at home; or are an English language learner.

Cost:

- **$330 per participant (2-year average)**
- **$1,222 per new subscriber**

Additional Information:

- 91% of participants subscribe to broadband 6 months after the program, compared with 64% before starting the program.
- Cost per participant is decreasing (fall 2016 cost was only $150 per participant).
- Program does not pay for participants' internet service.
- Participants can receive discounts for up to two devices if they have two or more children in Hamilton County schools and complete the program for each child; all others limited to one discounted device through the program every two years.

Connect Home Initiative (Nashville)

Overview: Participants who complete 3 hours of digital literacy training provided by Nashville Public Library or non-profit partners receive free broadband-enabled device and free broadband service through partnerships with broadband providers for residents in Metropolitan Development and Housing Agency communities (MDHA).

Eligibility: Participants must live in one of MDHA's communities where Google has expanded its Google Fiber internet service.

Cost:

- **$145 per participant**
- **$537 per new subscriber**

Additional Information:

- Data on effectiveness not available. Similar program in Chattanooga has resulted in 91% of participants subscribing to broadband 6 months after the program, compared with 64% before starting the program.
- Vanderbilt University's donation of used computers helps reduce overall cost of program related to obtaining devices for participants.
- Program does not pay for participants' internet service, though service is provided for free by at least one provider at the MDHA communities eligible for program.

Connect Home Initiative (Memphis)

Overview: Participants receive free broadband-enabled devices and broadband service that is either free or discounted depending on the availability program funds.

Eligibility: Participants must be residents of Memphis Housing Authority communities and participation is subject to availability of devices.

Cost:

- **$10 per device per month.**

Additional Information:

- Data on effectiveness not available.
- Cost pays for participants' internet service but is subject to availability of funds from partner organizations.

Library Programs and Resources

Hotspot Device Lending Programs

Overview: Libraries lend hotspot devices for accessing mobile broadband to library patrons. Hotspots can be used wherever there is mobile broadband service and can be turned off remotely if not returned.

Eligibility: Devices available to anyone with library card.

Cost:

- **$32 per device per month for broadband service (devices are free)**
- **$1.6 million per year to deploy enough devices in libraries statewide to achieve ratio of 1 device per 1,500 residents.**

Additional Information:

- Effectiveness depends on mobile broadband coverage.
- Some libraries defray costs by charging nominal fee (e.g. $1 per day) for devices.
- Libraries report that devices are among most popular items.

Digital Literacy Training and Resources

Overview: Voluntary technology services guidelines adopted by Tennessee State Library and Archives (TSLA) encourage libraries serving at least 5,000 patrons to offer meeting space and devices to community organizations for digital literacy training. Libraries are also encouraged as part of guidelines to provide digital literacy training several times a year depending on size, ranging for once per quarter for smaller libraries to twice per month for larger libraries.

Eligibility: Services available to all residents

Cost:

- **$144,640 per year to ensure that all libraries meet the voluntary guidelines.**

Additional Information:

- No data available on effectiveness of training provided by libraries at increasing rates of broadband adoption.
- More than 13,000 people attended trainings as part of programs that provided 60 hours of training in each of 70 libraries from June 2010 to June 2012 as part of a partnership between TSLA, the Tennessee Department of Economic and Community Development, and the US Department of Agriculture.
- Approximately 75% of libraries serving at least 5,000 patrons currently meet the voluntary standards, according to TSLA.

Public School Programs and Resources

Affordable Laptop Program

Overview: Provides school districts with a purchasing model that allows them to enter three year contracts with approved vendors to lease devices for students. Devices are replaced every three years.

Eligibility:

- Vendors must agree to the program's basic criteria regarding leasing and replacing devices to be approved.
- Districts that choose to work with an approved vendor will not be subject to the state restriction against making multiyear budget commitments.

Cost:

- **$5 per student per month**
- **$57.7 million per year to provide devices to every public school student in state**

Additional Information:

- Program not yet available.
- Several leading vendors have already expressed interest in participating.
- Annual cost calculated using 2015-2016 Average Daily Membership (ADMS) for total number of public school students.

Microsoft Imagine Academy

Overview: Provides instruction on using Microsoft Office suite of products as well as software development.

Eligibility: Tennessee Department of Education is considering purchasing a statewide license so that program resources will be available to every high school student in state.

Cost:

- **$440,000 per year for a statewide license**

Additional Information:

- Data on effectiveness not available.
- Several school districts already subscribe to program individually.

Provider-Led Programs

Broadband Service Discounts

Overview: Various providers have programs that offer eligible subscribers broadband service that typically meets the minimum 10/1 standard for around $10 per month, though service and price vary by provider.

Eligibility: Varies by provider but typically restricted to individuals or families who participate in certain federal or state public assistance programs. In many cases, eligibility is further restricted to those who have not recently subscribed to broadband service and who do not have outstanding debt to the provider.

Cost:

- **Costs covered by broadband providers. No additional costs to state or local governments**

Additional Information:

- Some providers also offer access to device discounts and digital literacy training resources.
- Eligibility has been expanded in some communities.

Federal Programs

Lifeline Program

Overview: Participants receive $9.25 per month discount on broadband service

Eligibility: Household's with income no more than 135% of federal poverty guidelines or with at least one member eligible for a variety of federal or state public assistance programs, including Medicaid, Supplemental Nutrition Assistance Program, Supplemental Security Income, Federal Public Housing Assistance, or Veterans Pension and Survivors Benefit.

Cost:

- **Funded through federal Universal Service Fund by a tax on wired and wireless telephone service.**

Additional Information:

- Data on effectiveness unavailable; program expanded to include broadband beginning December 2016.
- Program does not offer device discounts. While some providers offered free devices to participants in the program when it applied to telephone service alone, it is too early to tell whether they will offer free or discounted broadband-enabled devices now that the program has been expanded.

E-Rate for Schools and Libraries

Overview: Subsidizes up to 90% of the cost of broadband infrastructure and service for schools and libraries. Size of subsidy varies depending both on whether a school or library is located in an urban or rural area and on the level of poverty in the community a school or library serves.

Eligibility:

- Public schools and other non-profit schools with endowments no greater than $50,000,000.
- Libraries, public or non-profit, whose budgets are completely separate from those of any schools.

Cost:

- **Funded through federal Universal Service Fund by a tax on wired and wireless telephone service.**

Additional Information:

- Schools in Tennessee receive a subsidy of 86% on average through E-Rate, according to the Tennessee Department of Education.
- Many libraries in Tennessee receive subsidies of between 80% and 90%, according to TSLA.

Healthcare Connect Fund

Overview: Subsidizes 65% of the cost of broadband infrastructure and service for public and non-profit health care providers in rural areas.

Eligibility:

- Public and non-profit healthcare providers in rural areas.
- Public and non-profit healthcare providers not in rural areas are also eligible but only as part of consortia in which more than 50% of sites are rural healthcare providers and if provider has more than 400 licensed patient beds, it may receive no more than $30,000 per year in subsidies for recurring costs and no more than $70,000 in subsidies every five years for non-recurring costs.

Cost:

- **Funded through federal Universal Service Fund by a tax on wired and wireless telephone service.**

Additional Information:

- Rural healthcare providers rely on this federal funding to defray the costs of broadband service necessary for telemedicine programs and managing electronic health records.

Coordinating Local Planning	
	Connected Nation
	Overview: Through its state affiliates, works with communities to assess local needs and resources for improving broadband access, adoption, and use. Helps communities develop plans for meeting broadband needs. Eligibility: • No specific eligibility requirements. Ability to assist communities depends on funding. **Cost:** • **Connected Nation's affiliate in Michigan has an annual budget of around $375,000 and assists approximately 16 communities per year.** Additional Information: • Connected Nation's Tennessee affiliate, Connected Tennessee, was active until 2015 when its funding, which was primarily through the American Recovery and Reinvestment Act, ran out.

Toward Universal Broadband Adoption and Service in Tennessee

Broadband—high-speed internet service—has become a necessity in the 21st century for supporting economic development, agriculture, and access to educational opportunities and quality health care. Internet service of ten megabits per second download and one megabit per second upload meets the needs of most individual residential users performing single tasks. More than 93% of Tennesseans live in areas where providers report offering wireline or fixed wireless internet of at least 10/1. While this service is enough for most individuals, it is not enough for all users or tasks, and as a result, the Federal Communications Commission (FCC) defines broadband as a service of at least 25 megabits per second download and three megabits per second upload. Even 25/3 isn't enough for some businesses and industries, and the FCC recommends connections of at least 100 megabits per second for schools and libraries depending on the size of the populations they serve. Fortunately, 89% of Tennesseans live in areas where providers report offering wireline or fixed wireless internet that meets the FCC's broadband standard of 25/3. But the availability of 25/3 service is still limited in many rural communities. Moreover, only 40% of households with access to 25/3 service have chosen to adopt it. Because of this, at TACIR's June 2015 meeting, Chairman Mark Norris requested the Commission study ways to improve broadband availability and adoption in Tennessee (appendixes A and B). Fortunately, there are already several government and private initiatives to increase rates of broadband adoption and expand coverage.

Broadband Is a Critical Enabler for Economic Growth

Broadband is synonymous with improved standards of living and economic development. There is a general consensus among government officials and the private sector that increasing broadband use by encouraging widespread adoption and improving access in unserved and underserved areas is essential today. Broadband is a "critical enabler" that "supports economic growth through innovation and productivity," according to the US Telecom Association.[6] Similarly, the FCC, in its 2010 National Broadband Plan, calls broadband

> a platform to create today's high-performance America—an America of universal opportunity and unceasing innovation, an America that can continue

[6] US Telecom Association 2013.

> to lead the global economy, an America with world-leading, broadband-enabled health care, education, energy, job training, civic engagement, government performance and public safety.[7]

Without broadband, according to the Institute for Local Self Reliance, a non-profit that advocates for community development, "businesses wither, students are at a disadvantage, economies become less competitive, and home values decline."[8] Particularly for economic development, education, health, and agriculture, broadband is an increasingly important utility.

In part because of its increasing importance to everyday life, comparisons are often made between broadband and the expansion of electric service in the twentieth century.[9] While similarities do exist, comparisons between the two are imperfect. In particular, the expansion of electric service, unlike broadband, occurred within protected markets. While natural gas and oil were available for residential, commercial, and industrial energy use at midcentury, electric utilities were granted local monopolies that protected them from competition with other electric providers. In contrast, the Federal Telecommunications Act of 1996 directs the FCC and the states to

> encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans (including, in particular, elementary and secondary schools and classrooms) by utilizing . . . measures that promote competition in the local telecommunications market, or other regulating methods that remove barriers to infrastructure investment.[10]

Economic development depends on broadband.

Broadband is necessary for most communities looking to secure their economic futures. It helps local businesses grow in competitive markets, and it provides access to resources that help workers develop the skills they need to succeed. Communities that lack broadband infrastructure have difficulty attracting and retaining industries as well as recruiting skilled workers. According to the FCC's 2010 National Broadband Plan,

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[7] Federal Communications Commission 2010a.
[8] Mitchell 2012.
[9] Tennessee Department of Economic and Community Development 2016; and Mitchell 2012.
[10] Federal Telecommunications Act of 1996, Public Law 104-104, Section 706(a); also at 47 US Code 1302(a).

> broadband and the Internet make it possible for small businesses to reach new markets and improve their business processes. They have also become a critical pathway for individuals to gain skills and access careers. And it is a core infrastructure component for local communities seeking to attract new industries and skilled work forces. As a result, small businesses, workers, and communities must have the broadband infrastructure, training and tools to participate and compete in a changing economy.[11]

Recent research has found correlations between broadband and local economic growth. While existing studies do not demonstrate causal relationships between either broadband access or adoption and local economies, they do show that increases in access and adoption are associated with gains for communities and individuals, particularly in rural areas. Broadband adoption rates above 60% are associated with greater growth in household income in counties with less than 50,000 people where fewer than 25% of residents commute to a neighboring city. These relatively rural counties with high adoption rates also had significantly lower growth in unemployment than similar counties with lower adoption rates.[12]

In addition to adoption, the expansion of broadband access at the local level is associated with increases in employment, especially in technology intensive industries such as information and finance.[13] Other studies show that rural communities that received broadband access earlier than their peers had higher increases both in private earnings and in the number of non-farm proprietors.[14]

Businesses consider broadband infrastructure when determining where to locate. Access to broadband is just as necessary in the site selection process as access to water, sewer, power, and transportation for many industries, according to economic development professionals. Communities are unlikely to win projects because of broadband access alone. But the absence of broadband is enough to remove them from consideration.[15] Almost 45% of development agencies that participated in a recent Tennessee Department of Economic and Community Development (ECD) survey reported that businesses either frequently or occasionally chose

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[11] Federal Communications Commission 2010a.
[12] Whitacre et al. 2014.
[13] Ibid.
[14] Kolko 2012.
[15] Telephone interview with Clay Walker, chief executive officer, Networks Sullivan Partnership, July 26, 2016; and telephone interview with Don Hurst, business development consultant, Tennessee Department of Economic and Community Development, July 26, 2016.

not to locate in their communities because of insufficient broadband. Businesses that chose to participate in ECD's survey also reported that access to broadband affected their location decisions. More than one third said broadband was essential for selecting their location, and more than half said it was essential for remaining in their current location.[16]

Broadband is a vital resource in education.

Students and teachers need access to broadband inside and outside the classroom to take advantage of educational opportunities. According to the State Educational Technology Directors Association, a non-profit organization dedicated to improving education through technology policy and practice,

> broadband has become *the* enabling technology of modern learning environments. It is the medium through which educators are expanding the very boundaries of the classroom. A broadband Internet connection makes it possible for educators and students to access innovative tools and resources and to collaborate and interact with experts worldwide. It is now a basic requirement of learning environments that has become essential for educators, students, and administrators. Fast, always-on connections make it practical to tap into dynamic online content; to take advantage of evolving collaboration technologies; to provide self-directed and self-paced programs; to support mobility with anywhere, anytime learning; to enable time-saving and cost-effective professional development opportunities; and to leverage the numerous advantages of content, applications, and services delivered over cloud-based computing systems.[17]

Broadband will only become more important as schools move toward educational models that emphasize personalized learning, which usually involves tailoring instruction to individual students.[18] The wide array of educational resources that broadband places at students' and teachers' fingertips facilitates this customizable approach to education.

Broadband increases distance learning opportunities by providing access to video lectures and the ability to participate remotely in classroom

[16] Tennessee Department of Economic and Community Development 2016.
[17] Fox et al. 2012.
[18] Fox and Jones 2016.

discussions. Distance learning programs allow students to take courses that would not otherwise be available to them. In a 2014 report on distance learning in southwest Tennessee, the US Department of Education's Institute of Education Sciences says that

> by allowing schools to pool teaching resources and share courses, [distance learning] can be especially useful in rural schools that do not always have enough students to form a full class. If two (or more) schools share a course, students at both schools can take a class that neither school might otherwise have been able to offer.[19]

Working adults and those who cannot travel also benefit from the distance learning opportunities provided by broadband. Tennessee's colleges and universities as well as those in other states offer a variety of online degree and certification programs. These programs can help individuals obtain the skills they need to advance their careers or find new employment.

Broadband's benefits extend to teachers and parents. The internet provides teachers with access to professional development opportunities, and it makes it easier for them to share resources. Broadband can also help parents stay more involved in their children's education. According to a 2015 report by Education Superhighway, a non-profit focused on upgrading internet access in schools,

> teachers now have access to an unprecedented library of professional development tools, the ability to share resources with other educators across the country, and tools that help with classroom management and standards-based academic data tracking. Additionally, the expansion of technology in classrooms allows parents to be more involved than ever with their children's academics through tools such as online grade books, real-time behavioral and academic progress reports, and parent/teacher conferences via streaming video that can take place more often and with less coordination.[20]

Broadband increasingly touches all aspects of education. It is a vital resource for students, teachers, and parents as instruction and schoolwork move online, and it improves access to educational opportunities, especially in rural areas.

[19] Holian et al. 2014.
[20] Education Superhighway 2015.

Broadband supports advances in health care.

Patients and healthcare professionals both benefit from broadband's ability to support several applications of telemedicine, including the use of electronic health records (EHR), video consultation, and remote patient monitoring. According to the US Government Accountability Office's (GAO) report on the FCC's management of its rural health care program,

> telemedicine technologies can allow rural patients to receive, through remote access, medical diagnosis or patient care, often from specialists who are located in urban areas or university hospitals. Increased use of video consultation, remote patient monitoring, and electronic health records enabled by telemedicine technologies hold the promise of improving health care quality, safety, and efficiency. . . . Access to reasonably priced telecommunications services and Internet access services affords rural health care providers the ability to provide important telemedicine technologies that can improve the care of patients while maximizing limited resources.[21]

By facilitating these different applications of telemedicine, broadband improves access to efficient, high-quality health care. Electronic health records help doctors and nurses access and manage patient information, while video consultations provide access to specialists and save patients time, especially in rural areas, and remote patient monitoring can reduce hospital readmissions. The FCC's 2010 National Broadband Plan further describes the telemedicine related benefits of broadband:

> **Broadband and Electronic Health Records**
>
> Physicians report that electronic health records improve patient care in many ways. The e-prescribing component of EHRs helps avert known drug allergic reactions and potentially dangerous drug interactions, while facilitating the ordering of laboratory tests and reducing redundancy and errors. EHRs also provide easier access to critical laboratory information and enhance preventive care. For example, influenza and pneumonia vaccination reminders displayed to clinicians during a patient visit could play a part in saving up to 39,000 lives a year.

[21] US Government Accountability Office 2010.

According to one study often cited, electronic health record systems have the potential to generate net savings of $371 billion for hospitals and $142 billion for physician practices from safety and efficiency gains over 15 years. Potential savings from preventing disease and better managing chronic conditions could double these estimates.

Hosted EHR solutions tend to be more affordable and easier-to-manage alternatives for small physician practices and clinics. In certain settings, they cost on average 20% less than on-site solutions, reduce the need for internal IT expertise and provide timely updates to clinical decision-support tools (e.g., drug interaction references and recommended care guidelines).

Broadband and Video Consultation

Video consultation is especially beneficial for extending the reach of under-staffed specialties to patients residing in rural areas, Tribal lands and health professional shortage areas (HPSAs). For example, the American Heart Association and American Stroke Association recommend use of video consultation technology for stroke patients to help overcome the dearth of neurologists and to make decisions about whether to deliver the life-saving, clot-busting drug known as tPA.

In addition to increasing access to otherwise unavailable care, video consultations combined with store-and-forward technologies (e.g., sending images to a specialist at night, as opposed to obtaining a diagnosis during a patient's visit) could lead to significant cost savings from not having to transport patients. Avoiding costs from moving patients from correctional facilities and nursing homes to emergency departments and physician offices, or from one emergency department to another, could result in $1.2 billion in annual savings.

Video consultation and remote access to patient data may also be critical during pandemic situations. If hospitals are at capacity or if isolation protocols are necessary to prevent the spread of infection, these technologies can help health care providers assist more patients and help patients avoid public areas.

Broadband and Remote Patient Monitoring

Remote patient monitoring enables early detection of health problems, usually before the onset of noticeable symptoms. Earlier detection allows earlier treatment and, therefore, better outcomes. For example, after an initial hospitalization for heart failure, 60% of patients are readmitted at least once within six to nine months. If a congestive heart failure patient has a common problem indicator, such as increase in weight or a change in fluid status, a monitoring system instantly alerts the clinician who can adjust medications, thereby averting a hospital readmission. Estimates indicate that remote monitoring could generate net savings of $197 billion over 25 years from just four chronic conditions.[22]

The evolution of health care in the 21st century relies on broadband. Without broadband, the efficient exchange of patient information and the removal of geographic barriers to quality care would not be possible.[23]

Agriculture increasingly relies on connectivity provided by broadband.

As the number of devices that are connected to the internet increases, the need for reliable, high-speed connections will only grow. This is especially true in agriculture, where increased connectivity allows farmers to improve their operations, according to comments of the Tennessee Farm Bureau Federation at the Commission's October 2015 meeting.[24] Wireless sensors located in fields and on drones allow farmers to monitor soil conditions as well as the health of crops and livestock.[25] When combined with real-time weather data, farmers can analyze the information collected from these sensors to determine precise amounts of nutrients, water, seed, and pesticide needed to maximize yields.[26] Sensors on farm equipment can report mechanical problems and can be used in conjunction with GPS systems to ensure that tractors and combines are driven on precise routes through fields, allowing farmers to reduce the spacing between crops so that more can be planted per acre.[27] These sensors all rely on broadband to transmit and receive information, and broadband is also necessary for farmers to download the data that these sensors produce so that they can be analyzed. The gains in operational efficiency that broadband supports

[22] Federal Communications Commission 2010a.
[23] Ibid.
[24] Tennessee Farm Bureau Federation 2015.
[25] Long 2015.
[26] Tennessee Farm Bureau Federation 2015.
[27] Long 2015.

are necessary for farmers to remain competitive in global agriculture markets, according to Tennessee Farm Bureau.[28]

Broadband Is Defined by Users' Needs

Broadband is high-speed internet service that "enables users to originate and receive high-quality voice, data, graphics, and video," according to the Federal Communications Commission (FCC).[29] Speed is affected both by capacity and by the amount of time it takes data to travel from one end of a network connection to another, both of which are dependent on the wired and wireless technologies used to provide service. But regardless of technology, whether a network connection's speed is fast enough to support broadband quality service is largely dependent on the activities for which it is used and the number of individuals using it.

Capacity of 10 megabits per second download and 1 megabit per second upload is the bare minimum for broadband.

Much like highways, internet networks have limited capacities. Only so many vehicles can pass through a section of road in a given amount of time, and only so much information can be transmitted over internet networks. Moreover, just as surface streets and interstates have different capacities and just as traffic at any point between two locations will slow travel times regardless of whether it occurs on a two-lane road or an eight-lane highway, the limited capacities of internet networks can slow the transmission of information regardless of whether the source of a bottleneck is in a user's local network or the regional, national, and international networks that form the infrastructural backbone of the internet.

A network's capacity is the amount of data measured in binary units of computer code called bits that it can send or receive per second. Every image, every piece of text, audio, or video sent or received over the internet is transmitted as a string of bits—ones and zeroes—that eventually get translated into what we see and hear.[30] While individual file sizes are usually listed in bytes, a byte is just another measure of the number of bits that make up a file—one byte is equal to eight bits. Smaller files, such as simple emails and text-only webpages, may be made up of several thousand bits; large files, such as feature length movies and complex radiological image collections, may be several billion (see table 2). The number of bits per second that can be transmitted over a network affects the amount of time it takes to access websites and send or receive files,

[28] Tennessee Farm Bureau Federation 2015.
[29] Federal Communications Commission 2015d.
[30] EURIM 1999.

such as emails and pictures, and it affects the quality of tasks that involve streaming data continuously, such as watching videos or teleconferencing.

For networks to provide broadband, they must have capacities large enough to support users' needs for receiving and sending high-quality video, audio, text, and graphics. Networks have separate capacities for downloading—receiving information from the internet—and uploading—sending information to the internet. Residential users typically require larger capacities for downloading than uploading. According to the FCC, "although . . . in the future applications may require higher upload speeds or speeds that are more symmetric with download speeds, nothing in the record or the market convinces us that such need is imminent."[31]

The minimum download capacity necessary to provide broadband is ten megabits per second—one megabit is one million bits. Capacities greater than ten megabits per second provide little noticeable improvement when accessing websites. According to the FCC,

> beyond 15 megabits per second, performance increases for basic web browsing diminish dramatically. The data indicate that a consumer subscribing to a 10 megabits per second speed tier is unlikely to experience a significant performance increase in basic web browsing—e.g., accessing web pages, but not streaming video or using other high-bandwidth applications such as video chat—by moving to a higher speed tier.[32]

At ten megabits per second, small files less than one megabyte in size, such as text-only emails and emails with small attachments, download in less than one second, and moderately sized files of around 40 megabytes, such as a photo album with approximately 20 pictures, download in less than one minute. See table 2 and appendixes C and D.

Users can also watch high definition videos and participate in teleconferencing with download capacities of ten megabits per second. Major online video providers recommend around five or six megabits per second for viewing high definition videos, while for standard definition, they recommend two or three megabits per second.[33] The calling service Skype recommends a minimum of only 0.3 megabits per second for individual video calls; it recommends two megabits per second for three-person video conferences and eight megabits per second for video conferences with at least seven people.[34]

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[31] Federal Communications Commission 2015d.
[32] Federal Communications Commission 2014c.
[33] Netflix "Internet Connection Speed Requirements"; and Apple 2016.
[34] Skype 2016.

Table 2. Time Required to Perform Various Internet Tasks Depending on Connection Capacity

Type of File	Bytes	5Mbps	10Mbps	25Mbps	100Mbps	1Gbps	10Gbps
• Text e-mail without attachments • Web browsing • E-mail with large attachments or graphics • Download small files (e.g., a 50-page text document with limited graphics)	1MB	1.6sec	<1sec	<1sec	<1sec	<1sec	<1sec
• Download large files (e.g., a 50-page text document with graphics)	2MB	3.2sec	1.6sec	<1sec	<1sec	<1sec	<1sec
• 3 minute song	5MB	8sec	4sec	1.6sec	<1sec	<1sec	<1sec
• Music files • Trailer or short video • Complete website • Hand MRI scan	10MB	16sec	8sec	3.2sec	<1sec	<1sec	<1sec
• 20 Photographs	40MB	1min	32sec	12.8sec	3.2sec	<1sec	<1sec
• Photo or music album • Operating System software update • Head, cardiac or abdomen PET • MRI or CT scan	100MB	3mins	1min	32secs	8secs	<1sec	<1sec
• 5 minute video	200MB	5mins	3mins	1min	16secs	1.6secs	<1sec
• 1 hour movie or TV show • Upload videos and presentations • 200 image CT scan	1GB	27mins	13mins	5mins	1mins	8secs	<1sec
• Windows 10 download	3GB	1hr	40mins	16mins	4mins	24secs	2.4secs
• Daily incremental server backup	20GB	9hrs	4hrs	2hrs	27mins	3mins	16secs
• Audio/movie collection • PC or server backup	1TB	19days	9days	4days	22hrs	2hrs	13mins
• Research file collection • Hospital or laboratory image collection	1PB	51yrs	25yrs	10yrs	3yrs	93days	9days

Note: Times are for one user performing one task at a time. Above one minute, times are rounded to nearest minute, day, or year.

Source: Hazlewood and Mezzacappa 2016 (see appendix C); Columbia Telecommunications Corporation 2010 (see appendix D); and Executive Office of the President 2015.

The minimum upload capacity for broadband is one megabit per second. Small files such as emails will still upload in a matter of seconds (see table 2). And according to the FCC, "most broadband services require relatively low upload speeds."[35] While video conferencing does use a network's upload capacity, Skype only recommends users have more than one megabit per second upload for high-definition service.[36]

The FCC uses ten megabits per second download and one megabit per second upload (10/1) as a standard for several of its subsidy programs, including the Connect America Fund phase II program and the Lifeline program. The Connect America Fund phase II provides grants to broadband providers to subsidize the cost of expanding coverage in high-cost areas. Providers are required to use funds to offer service of at least 10/1 in areas where it is not available. This will ensure that these high-cost areas receive broadband service that is at least "reasonably comparable" in terms of capacity to areas that already have access to broadband, according to the FCC.[37] The Lifeline program provides discounts to consumers on their monthly service plans. To be eligible for discounts under the program, service plans for fixed broadband must have capacities of at least 10/1, though in areas where a provider does not offer service of at least 10/1, fixed service of at least four megabits per second download and one megabit per second upload is also eligible for the program.[38]

Communities need at least 25 megabits per second download and 3 megabits per second upload to take full advantage of broadband.

While 10/1 capacity supports most individual tasks that residential users perform, communities without access to higher capacities are underserved. Networks are often shared among multiple users, and individuals often use the internet for more than one task at once.[39] Capacity is shared among all those simultaneously using a network and their tasks. According to the FCC,

> a benchmark of 25 [megabits per second download] and 3 [megabits per second upload] is better suited than a benchmark of 10 Mbps/1 Mbps for evaluating whether a household has access to advanced services. When we look at providers' statements about what bandwidth is necessary to use particular services, and when we

[35] Federal Communications Commission 2015d.
[36] Skype 2016.
[37] Federal Communications Commission 2014b
[38] Federal Communications Commission 2016i.
[39] Federal Communications Commission 2015d.

> take into account that most households include more than two people, that household members routinely use multiple broadband services simultaneously, and that even a single person often uses more than one broadband service at the same time, we find that service of at least 25 Mbps/3 Mbps is the best speed by which to assess broadband availability. While 10 Mbps/1 Mbps suffices for many basic household uses . . . it is not adequate for all household broadband needs.[40]

Communities with access to capacities of at least 25/3 are better able to support local businesses' needs. Almost 25% of businesses surveyed by the US Small Business Administration in 2010 said they need more than ten megabits per second, and almost half said they want more than ten megabits per second.[41] Small businesses also "tend to subscribe to mass market broadband service," according to the FCC, rather than contract for specific broadband needs like a large industry might.[42] Tennesseans who operate businesses out of their homes—including 9,815 firms with almost 28,000 employees—will also benefit from higher capacity service.[43]

Larger users, including industries and anchor institutions such as hospitals, schools, and libraries, need higher capacities than even 25/3. Industrial users and hospitals need high capacities to transfer large files in reasonable amounts of time. A collection of 200 radiological images that might be as big as one gigabyte—1,000 megabytes—would take more than ten minutes to download or upload over a ten megabits per second capacity network, compared with approximately ten seconds over a network with a capacity of one gigabit per second—a gigabit is 1,000 megabits. Similarly, backing up all of an industry's files, which might total one terabyte in size—a terabyte is one million megabytes—would take nine days over a network with a capacity of ten megabits per second, compared with only two hours over a one gigabit per second network. See table 2 and appendixes C and D.

Schools and libraries also need higher capacity networks to support multiple users at once. The FCC recommends that schools have networks with capacities of 100 megabits per second per 1,000 students and staff in the short term with a long-term goal of one gigabit per second per 1,000 students and staff. Similarly, the FCC adopted the American Library Association's targets that all libraries serving fewer than 50,000 patrons have networks with capacities of at least 100 megabits per second and

[40] Ibid.
[41] Columbia Telecommunications Corporation 2010.
[42] Federal Communications Commission 2016h.
[43] US Department of Commerce, Bureau of the Census 2014.

that all libraries serving more than 50,000 patrons have networks with capacities of one gigabit per second.[44]

Lag also affects whether internet service is fast enough to qualify as broadband.

In addition to capacity, speed is affected by the amount of time it takes signals to travel from one end of a network to another or from one user's device to another. The lag between when a signal is sent and received—commonly referred to as latency—is usually measured in thousandths of a second—milliseconds. Lag, according to the FCC, "may affect the perceived quality of highly interactive applications such as phone calls over the Internet, video chat, or online multiplayer games."[45] It can render an internet connection too slow to support tasks that require real-time communication, including voice calling, even if the connection has enough capacity to support them. Lag times of even one-fifth of a second can be unacceptable for calls, according to Skype.[46]

Technology for providing broadband continues to evolve.

Broadband is provided using a variety of networks and technologies. The local networks that serve individual communities are connected to form regional, national, and international networks that make the internet what it is: a network of networks that connects users to facilitate communication and the flow of information. In general, these networks can be broken into four segments, including the

- backbone,
- middle mile,
- last mile, and
- last 100 feet.[47]

As described by Charles Eldering, an engineer with more than 20 years of experience in telecommunications, in *Communications Deregulation and FCC Reform: Finishing the Job*,

> the backbone segment provides for long-distance, high capacity, high-speed transfers of data. . . . Investment in these facilities has been significant, with the result that capacity has been consistently able to keep pace with

[44] Federal Communications Commission 2015d.
[45] Federal Communications Commission 2016h.
[46] Skype 2011.
[47] Eldering 2001.

> demand, at least in major metropolitan areas. These facilities rely mainly on fiber optic cables, but they make use of terrestrial wireless and satellite-based systems as well. Although backbone congestion does occur, there is, in general, no lack of optical bandwidth or competitive transport services.
>
> Middle mile segments can range from a few miles to a few hundred miles. They are most often constructed of fiber optic lines but can make use of microwave and satellite transmissions as well. These types of segments were originally built by telephone and cable companies for ordinary telephony or cable television delivery service. In the traditional telecommunications companies, these segments have served to connect main offices or, in industry parlance, PoP (Points of Presence) to the backbone network. . . .
>
> The remaining segments, the last mile and the last 100 feet, are the segments in which considerable investments are required to support broadband. This is also where broadband delivery strategies diverge.[48]

Local broadband networks—the so-called last mile and last 100 feet of a network—provide service to end-users via a variety of technologies, including

- copper wires originally for telephone service,
- coaxial cables originally for television service,
- fiber-optic cables, and
- wireless transmitters and receivers both terrestrial-based and satellite.

These technologies support different network infrastructures. Copper telephone wires support Digital Subscriber Line (DSL) internet services offered by telephone companies, while coaxial cables support cable modem services offered by cable television providers. Fiber-optic cables are used to provide service directly to customer premises by some providers but can also be used to increase the capacities of DSL networks and cable modem networks, though in these hybrid networks the final connection to subscribers is still made over copper wires or coaxial cables. Wireless networks include satellite service as well as terrestrial-based services such as fixed wireless, which provides internet to specific locations, and mobile

[48] Ibid.

wireless, which provides service directly to phones and other devices. See appendix E.

Each of these network infrastructures and technologies has different physical properties and technical specifications that affect performance, but they are all capable of supporting internet service. LinkIDAHO, the state of Idaho's broadband mapping and planning initiative, describes each type of broadband network:

> **Digital Subscriber Line (DSL)**
>
> Digital Subscriber Line (DSL) has been the primary broadband technology employed by telephone companies (common carriers) for a number of years because it makes good use of existing dedicated telephone lines (typically copper). With DSL, a single telephone line is used to deliver both voice and high-speed data transmission. Providing two (2) services over a single (1) line is possible because the data transmission takes place over a different (higher) frequency than the voice service.
>
> There are a number of variations or versions of DSL in the market (e.g., SDSL, ADSL, VDSL, etc.). The most common and less expensive version of DSL is Asymmetric Digital Subscriber Line (ADSL). As the name implies, this 'asymmetric' service provides download speeds that are different than the upload speeds. Download speeds are higher than upload speeds. Other versions of DSL include a symmetric version (SDSL) where the upload and download speeds are the same. . . .
>
> Using up to 7 different frequencies, very-high-bitrate DSL (VDSL or VHDSL) is one of the newer DSL technologies providing faster data transmission . . . . With these faster speeds, VDSL is capable of supporting high bandwidth applications such as HDTV, as well as telephone services (Voice over Internet Protocol, or VoIP) and general Internet access, over a single connection.
>
> As for speeds realized by DSL customers, the defining issue is distance from the telephone company's central office (CO). Due to electrical resistance in the telephone wire, the farther a customer is from the CO, the weaker the signal—and therefore the slower the

speed. It is commonly accepted with ADSL technology that broadband speeds . . . can be achieved up to approximately 10,000 feet (2 miles) from the nearest CO, although other factors such as wireline interference and network traffic can impact the speed consumers actually experience. Between 10,000 and 16,000 feet, speeds fall steadily to the point where they begin to match dial-up Internet service. Most customers cannot receive DSL if they live more than 16,000 feet (3 miles) from the nearest CO.

Cable Modem

As the name suggests, cable broadband uses the cable television infrastructure. Strategically cable access is similar to the DSL approach used by telephone companies—the difference is that cable service makes good use of the cable TV company's coaxial cable existing network while DSL service leverages an existing telephone company's plant. The connections between the cable company office (called the 'headend' as opposed to the Central Office in a telephone company) and the customer's premise is either a pure cable run or in more modern networks what's called a hybrid fiber coaxial (HFC) facility (i.e., a network that uses both fiber and coaxial lines).

In discussions regarding cable broadband, you'll often hear the term DOCSIS. Data over Cable Service Interface Specification (DOCSIS) is the international telecommunications standard that permits the addition of high-speed data transfer to an existing Cable TV (CATV) system. Due to the design of coaxial and fiber cable lines, cable speeds tend to be higher than traditional DSL speeds. . . . The maximum distance from the nearest headend that cable service can be offered is also typically much greater than with DSL service. However, cable lines are not nearly as ubiquitous as telephone lines. There may be installation charges for installing cable to new homes, and some homes may be too far from the nearest cable system for installation to be economically feasible.

Fiber Optics

Fiber optics are strands of optically pure glass that carry digital information as pulses of light. Each glass strand

is surrounded by a material that reflects the light back into the glass core and a coating to protect it. Hundreds of thousands of these coated glass strands are bundled together to make the fiber optic cable that delivers the Internet to your home or business. One advantage of fiber optics is higher transmission speeds.

Fiber to the x (FTTx) is a generic term for any broadband network architecture that uses optical fiber to replace all or part of the traditional local loop used for last mile (the connection between the customer and the telephone company, cable company or ISP) transport. The variations (i.e., what the "x" refers to) depend on how far the fiber extends toward the home (or business). For example:

- FTTN (Fiber-to-the-Node): fiber is terminated in a street cabinet up to several kilometers away from the customer premises with the final connection being copper.
- FTTC (Fiber-to-the-Cabinet or Fiber-to-the-Curb): this is very similar to FTTN, but the street cabinet is closer to the user's premises—typically within 300 meters.
- FTTB (Fiber-to-the-Building or Fiber-to-the-Basement): fiber reaches the boundary of the building, such as the basement in a multi-dwelling unit, with the final connection to the individual living space being made via alternative means.
- FTTH (Fiber-to-the-Home): fiber reaches the boundary of the living space, such as a box on the outside wall of a home.
- FTTP (Fiber-to-the Premises): this term is used in several contexts—as a blanket term for both FTTH and FTTB, or where the fiber network includes both homes and small businesses.

With broadband, it's primarily about speed. While the speeds of fiber optic and copper cables are both limited by length (i.e., distance from the central office and/or serving equipment), copper is much more sharply limited in this respect. Therefore, generally the further

fiber extends into the network, the higher the resulting end-user (realized) speeds.

Fixed Wireless

In a broad sense, wireless broadband access is either 'fixed' (transmission to/from a specific and stationary or static point) or 'mobile' (transmission to/from a device on the move). Consumer and business-level fixed wireless broadband is typically provided by companies known as Wireless Internet Service Providers (WISPs). WISPs employ networks of radios that transmit and receive broadband signals . . . . Some of these radios will be placed on single purpose towers and other high structures (e.g., water towers, buildings, etc.) and some on homes or businesses.

Fixed wireless technology may include commonplace Wi-Fi wireless mesh networking techniques, or proprietary equipment designed to operate over open . . . or licensed frequencies . . . . A single radio in the network can serve multiple end users depending on the volume of traffic experienced (bandwidth used) and the provider's oversell ratios. Oversell ratios (a strategy employed in nearly all broadband technologies) simply recognizes the fact that not all users are on the network at the same time. Fixed wireless providers typically operate in rural areas where DSL or cable broadband is not available (although there are exceptions where WISPs are taking advantage of unmet demand and service issues in more urban areas). At some point in their networks, the WISP will aggregate traffic and ultimately connect their radio-based facilities with an existing fiber or copper-based network, thereby gaining access to and from the Internet.

In most cases, fixed wireless access is what's called 'line of sight' in that the transmission is dependent on a clear path from the radio on a home to the radio on the tower. Obstructions in this transmission path (e.g., seasonal foliage) can interrupt service. Fixed wireless technologies are one of the most rapidly evolving of broadband technologies, with equipment providers announcing increased speed and reception capabilities on a regular basis. When evaluating fixed wireless, it's important that people speak with their local provider to

understand the capabilities of their current equipment and their plans for upgrading as the technology improves.

Mobile Wireless or Cellular Broadband

Mobile/cellular broadband covers a range of technologies employed by the likes of AT&T and Verizon Wireless to provide high-speed connections to end-user devices that are typically used on the move (e.g., smart phones, iPads, etc.).

Through the recent past, there have been two competing approaches to delivering mobile broadband service: Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA). GSM dominates the market outside the US. Domestic CDMA carriers include Verizon and Sprint and whoever uses their networks (e.g., Virgin, Boost). Our GSM carriers include AT&T and T-Mobile and whoever uses their networks. There are also several smaller cellular companies on both networks.

Both of these technologies continue to evolve into higher speeds. An example in the GSM world is HSPA (High Speed Packet Access). In the CDMA world, an example is EVDO (Evolution, Data Only or Evolution, Data Optimized). Both continue to develop faster networks. These faster networks are often referred to as 3G or the most recent development, 4G, which include LTE (Long Term Evolution) and WiMAX (both under the umbrella of Orthogonal Frequency Division Multiplexing (OFDM—a technique for transmitting large amounts of digital data over a radio wave). The 'G' simply stands for the 3rd or 4th 'generation' of these broadband cellular networks. . . . However, even within the 3G and 4G categories, there are several 'revisions' of the core technology with speeds and coverage constantly improving.

Satellite

You will typically find satellite broadband access in our rural areas where other technologies have not yet been deployed due to cost and/or insufficient demand. Satellite Internet is provided through low earth orbit (LEO) satellites. Different types of satellite systems

> have different features and technical limitations, which can greatly affect their usefulness and performance in specific applications. . . . Satellite broadband, because signals have to travel so far, also have much longer latency rates than other broadband technologies. In addition, reliability is also questionable in bad weather (e.g., rain fade) or during sunspot activity.[49]

All of these technologies and networks are capable of providing 10/1 service, though their maximum capacities differ. The latest advances in DSL can provide capacities of more than 300 megabits per second but only if the distance that signals travel over copper wires is less than approximately 330 feet.[50] Some providers in Tennessee reported offering DSL at capacities well above 25/3 as of December 2015, including several that reported capacities of up to 70 megabits per second download and 6 megabits per second upload or greater for residential customers.[51] But, according to the Columbia Telecommunications Corporation,

> in systems operated by large telecommunications companies, the average length [over copper wires] is 10,000 feet, corresponding to available DSL speeds between 1.5 Mbps and 6 Mbps. In systems operated by small companies in rural areas, the average length is 20,000 feet, corresponding to maximum speeds below 1.5 Mbps.[52]

Both cable modem networks and fiber to the premises networks have larger maximum capacities than DSL. The latest cable modem service can provide capacities of at least one gigabit per second download and 35 megabits per second upload,[53] with the possibility of ten gigabits per second download and upload in the future.[54] Providers reported offering cable modem service at capacities up to 250 megabits per second download and 20 megabits per second upload for residential customers in Tennessee as of December 2015.[55] This capacity, however, is "shared by all customers—typically hundreds of homes or businesses—on a particular segment of coaxial cable. . . . Speeds may decrease during bandwidth 'rush hours' when more users simultaneously use greater amounts of bandwidth."[56]

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[49] LinkIDAHO "Broadband Types."
[50] Pfanner and Scaturro 2016; and Columbia Telecommunications Corporation 2014.
[51] Federal Communications Commission 2016l.
[52] Columbia Telecommunications Corporation 2014.
[53] Brodkin 2016a.
[54] Hamzeh 2016.
[55] Federal Communications Commission 2016l.
[56] Columbia Telecommunications Corporation 2014.

Fiber to the premises networks can provide ten gigabits per second.[57] Several providers reported offering fiber to the premises service at capacities up to one gigabit per second download and one gigabit per second upload for residential customers in Tennessee as of December 2015.[58] At least one provider currently offers fiber service at ten gigabits per second, though it costs $299 per month.[59]

Fixed wireless can also provide capacities of at least 25/3. One fixed wireless provider recently purchased by Google offers service with capacities of up to one gigabit per second to commercial customers and residents of apartment buildings in several urban areas around the United States.[60] But much like cable, "residents share their building's bandwidth with each other, so performance may not always hit the lofty heights of 100 to 500 megabits per second," according to technology news website Ars Technica.[61] While several fixed wireless providers in Tennessee reported offering service with capacities of at least 25/3 to residential customers as of December 2015, capacities up to 15 megabits per second download and 3 megabits per second upload were more common.[62]

Broadband technologies are not always interchangeable.

The tasks users perform ultimately determine the type of broadband infrastructure they require. For residential and business users, satellite internet and mobile wireless are not comparable substitutes for wireline and fixed wireless broadband at this time. Both technologies are improving, and if recent innovations, particularly in mobile wireless, produce real-world results close to what they have in the lab, then they may be able to provide broadband equivalent to wired and fixed wireless technologies in the future. But present lag times for satellite service as well as capacity limitations and lower monthly data caps for both satellite and mobile wireless mean that communities that only have access to these technologies remain underserved.

While satellite internet service providers offer users connections of at least 10/1, they do not offer service of at least 25/3, according to the FCC.[63] In its 2015 broadband progress report, the FCC says that

[57] Zager 2015; and Finley 2015.
[58] Federal Communications Commission 2016l.
[59] Electric Power Board of Chattanooga 2016.
[60] Brodkin 2016b.
[61] Brodkin 2015b.
[62] Federal Communications Commission 2016l.
[63] Federal Communications Commission 2016h.

> satellite service providers today advertise that they offer speeds as high as 15 Mbps/2 Mbps, and likely have not yet deployed 25 Mbps/3 Mbps speeds or higher. Moreover, a large portion of the nation cannot subscribe to the highest speed satellites; the last generation of satellites serves the coasts, but is unavailable in much of the middle of the country. . . . Satellite capacity constraints may limit the number of subscribers that can subscribe to satellite broadband service.[64]

Satellite service also suffers from lag times that can degrade voice calls and other real-time communications because of the distance signals must travel to and from the satellite itself. The average lag time for satellite internet is more than 670 thousandths of a second, according to the FCC.[65] Although this may seem like an insignificant amount of time, it is more than three times Skype's recommended maximum for voice calling[66] and nearly twenty times longer than the average for both wireline and other wireless providers.[67] According to the FCC,

> latency . . . remains a particular concern for satellite broadband technology . . . and whether satellite service allows consumers to "originate and receive" high-quality broadband services, as required by section 706(b). Due to the distances between the satellite and terrestrial points, satellite had the highest measured latency of the fixed broadband technologies (satellite, DSL, cable, and fiber) of 671.1 milliseconds. The *2014 Fourth Measuring Broadband America Report* shows latency remains a concern for satellite service quality. Because satellite systems involve the transmission of information over long distances and have correspondingly higher latencies than for terrestrial technologies, ViaSat had a measured latency of 671.1 milliseconds, approximately 19 times the terrestrial average.[68]

Advances in satellite technology could provide service more comparable to wireline and fixed wireless technologies in the future. In particular, at least one provider offering service outside the United States now deploys its satellites closer to the earth, which it says has reduced lag times on its network to less than 150 thousandths of a second.[69] But the cost of

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[64] Federal Communications Commission 2015d.
[65] Ibid.
[66] Skype 2011.
[67] Federal Communications Commission 2015d.
[68] Ibid.
[69] Ibid.

operating these new satellites "will likely keep this technology out of reach for some time," according to the Appalachian Regional Commission.[70]

While mobile wireless networks can provide capacities above 25/3, they do not always do so consistently or reliably, according to the FCC. Tests of mobile networks conducted as part of ECD's 2016 survey showed capacities of up to 50 megabits per second, well above what is necessary for broadband service.[71] Peak capacities greater than 90 megabits per second download and 40 megabits per second upload have also been reported in urban areas.[72] But according to the FCC,

> consistency and reliability factors also differ as between mobile and fixed services. For instance, if the reported maximum advertised speed for a particular location is at or above 10 [megabits per second download] / 768 [kilobits per second upload], the [data] indicate that mobile broadband has been deployed in this location regardless of whether the maximum advertised speeds are available regularly or on rare occasion. Many factors, such as terrain, congestion, weather, structural boundaries, and tower placements can affect the consumer experience, and the fact that a provider advertises a maximum speed in an area does not establish that such speeds are regularly or ubiquitously available.[73]

While at least one mobile wireless provider says its users can expect download capacities up to 40 megabits per second, several other providers say that their users can expect less than 25 megabits per second download. The upper bound of their ranges for expected upload capacities are all greater than 3 megabits per second.[74]

Advances in mobile wireless network technology may provide service comparable to some of the fastest wireline and fixed wireless technologies in the future. Providers are already working on the next generation of fixed and mobile wireless network technologies—including so-called 5G wireless networks—which have provided capacities approaching four gigabits per second in testing.[75] However, these capacities have not yet been demonstrated for mobile service under real-world conditions,[76] and

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[70] Patterson et al. 2016.
[71] Tennessee Department of Economic and Community Development 2016.
[72] Segan 2015.
[73] Federal Communications Commission 2015d.
[74] T-Mobile "About T-Mobile"; Verizon 2016a; and AT&T 2016c.
[75] Cheng 2016.
[76] Scott 2016.

according to some reports, next generation wireless is likely to be used for fixed wireless networks first.[77] Another project, still in its experimental phase, could result in wireless signals capable of providing multi-gigabit per second capacities being sent along the outside of power lines—older technologies that used the power lines themselves have had only limited success.[78]

In addition to concerns regarding lag and capacity, both satellite and mobile wireless service providers currently restrict the amount of data that subscribers can use relative to similarly priced plans offered by wireline and fixed wireless providers. The typical wireline broadband subscriber uses approximately 100 gigabytes of data per month, according to one major provider.[79] Satellite internet providers report plans with data caps of up to only 70 gigabytes per month, according to the FCC.[80] Mobile wireless providers offer plans with data caps as low as one gigabyte per month, while mobile plans with caps of 100 gigabytes cost approximately $450 per month.[81] For both satellite and mobile wireless service, subscribers who exceed their data caps may have the capacity of their connections reduced below broadband quality for the rest of their billing cycle,[82] or they can purchase more data.[83] Even mobile wireless providers offering so-called unlimited data plans say users' capacities may be reduced after they have used more than approximately 28 gigabytes in one month.[84] In contrast, some wireline and fixed wireless providers offer service of at least 25/3 without caps for less than $100 per month,[85] and those that do have caps offer plans with caps of up to 1,024 gigabytes at capacities greater than 25/3 also for less than $100 per month.[86]

While mobile wireless and satellite are not currently comparable substitutes for other broadband technologies for residential and business users, other users rely on these wireless infrastructures for many of their broadband needs. In agriculture, in particular, wireline connections are inadequate for many important functions that rely on broadband. The sensors that transmit information about soil conditions and temperature require wireless connectivity. Similarly, wireless broadband is necessary to operate the guidance systems that help equipment such as tractors and combines follow precise routes through fields.[87]

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[77] Shankland 2016.
[78] Knutson 2016; and AT&T 2016b.
[79] AT&T 2016d.
[80] Federal Communications Commission 2015d.
[81] Verizon 2016b; and AT&T 2016e.
[82] Exede 2016a; and AT&T 2016e.
[83] Verizon 2016b; and Exede 2016b.
[84] T-Mobile "About T-Mobile."
[85] Athena 2015; and Google Fiber "Plans and Pricing."
[86] Comcast 2016c; and Comcast 2016a.
[87] Long 2015; and Tennessee Farm Bureau Federation 2015.

Too Many Tennesseans either Have Not Adopted Broadband or Don't Have Access to It

> Today, as technology continues to change the way the world interacts, to be on the outside is to live in a separate, analog world, disconnected from the vast opportunities broadband enables.[88]

Broadband must be made available, and Tennesseans must take advantage of it. Although coverage continues to expand, universal service is not yet a reality, especially in rural areas. Approximately 89% of Tennesseans live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 25/3 or better, according to data collected by the FCC in December 2015,[89] an increase of two percent from 2014[90] and seven percent from 2013.[91] More than 93% live in census blocks where at least one provider reported offering wireline or fixed wireless service of 10/1 or better as of December 2015,[92] an increase of four percent from 2013.[93] This represents the maximum extent of wireline and fixed wireless broadband coverage. The data do not say whether everyone in these census blocks has access to service at the reported capacities. For wireline and fixed wireless service, "providers file lists of census blocks in which they can or do offer service to at least one location, with additional information about the service," according to the FCC, but "a provider that reports deployment of a particular technology and bandwidth in a census block may not necessarily offer that service everywhere in the block."[94] See map 1 and appendix F.

Despite coverage gains, there are still 423,205 unserved Tennesseans living in census blocks where no provider reported wireline or fixed wireless coverage of at least 10/1, in addition to 302,336 living in underserved census blocks with access to service of at least 10/1 but less than 25/3. Rural areas are also less likely to have access than urban areas. Ninety-eight percent of Tennesseans in urban areas live in census blocks where at least one provider reported offering wireline or fixed wireless service with a capacity of 25/3 in December 2014, compared with only 66% of those in

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[88] Federal Communications Commission 2010a.
[89] TACIR staff calculations using FCC Form 477 data reported as of December 31, 2015, and population data from 2010 census.
[90] Federal Communications Commission 2016h.
[91] Federal Communications Commission 2015d.
[92] TACIR staff calculations using FCC Form 477 data reported as of December 31, 2015, and population data from 2010 census.
[93] Federal Communications Commission 2015d.
[94] Federal Communications Commission 2015a.

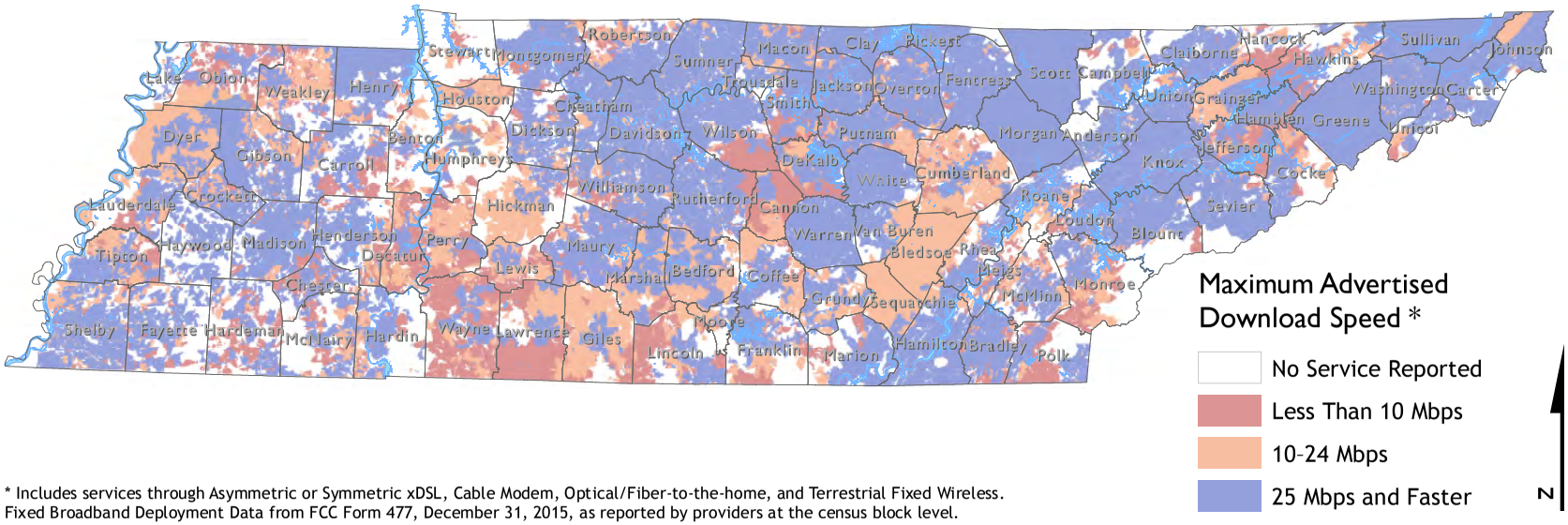
rural areas.[95] Providers report offering mobile wireless service and satellite service in almost every census block in the state.[96]

Overall, Tennessee ranks only 29th in the nation for wireline and fixed wireless coverage of at least 25/3, according to the FCC's 2016 Broadband Progress Report. Among southeastern states including the eight states that it borders and South Carolina, Louisiana, and Florida, Tennessee ranks 5th behind Georgia, North Carolina, Florida, and Virginia.[97]

Moreover, not enough Tennesseans have adopted broadband, though adoption has increased. Only 40% of Tennessee households located in census blocks where at least one provider reported offering at least 25/3 broadband subscribe to the service, according to the FCC's 2016 Broadband Progress Report.[98] While this is an increase of three percent from the year before, it still means a significant number of households could be subscribing to broadband but aren't.[99] Tennessee ranks better nationally and regionally for adoption than it does for coverage. Tennessee is tied for 19th out of 45 states for which the FCC reports adoption data. Among southeastern states, it is second, trailing only Virginia.[100]

[95] Federal Communications Commission 2016h.
[96] TACIR staff calculations using FCC Form 477 data reported as of December 31, 2015, and population data from 2010 census.
[97] Federal Communications Commission 2016h.
[98] Ibid.
[99] Federal Communications Commission 2015d.
[100] Federal Communications Commission 2016h.

Map 1. Maximum Advertised Download Speeds Reported by Providers in each Census Block in Tennessee as of December 2015.



* Includes services through Asymmetric or Symmetric xDSL, Cable Modem, Optical/Fiber-to-the-home, and Terrestrial Fixed Wireless.
Fixed Broadband Deployment Data from FCC Form 477, December 31, 2015, as reported by providers at the census block level.

Encouraging broadband adoption requires increasing its perceived value to users and reducing its cost.

Increasing broadband adoption is just as critical as expanding coverage. As broadband transforms education, health care, and the economy, "universal adoption is crucial because the economic and social costs of remaining unconnected are rising inexorably," according to Charles Davidson and Michael Santorelli, two New York Law School professors who have produced numerous studies on broadband.[101] Community anchor institutions can be important resources for individuals and families who don't have broadband at home, according to Connected Tennessee—the state's affiliate of the non-profit Connected Nation that collected information on broadband availability, adoption, and use—though not all anchor institutions in Tennessee have broadband (see appendix G).[102] Programs at schools and libraries, in particular, not only provide digital literacy training but also access to broadband service and devices for those who are either unable to afford them or who live in unserved and underserved areas. Other existing resources for encouraging adoption include the federal E-Rate and Lifeline programs and adoption programs run by non-profit organizations as well as those run by broadband providers. While there is no single model to encourage adoption, programs tailored to address specific barriers faced by individual populations have been effective.

Broadband adoption varies with age and income among other demographic characteristics.

Rates of broadband adoption differ across population groups. According to the FCC's 2010 National Broadband Plan,

> adults who do not use broadband at home generally are older, poorer, less educated, more likely to be a racial or ethnic minority, and more likely to have a disability than those with a broadband Internet connection at home.[103]

Surveys and analyses by several non-profits and government agencies reinforce the FCC's findings.[104] A 2015 survey by the Pew Research Center, for example, found that while approximately three-quarters of respondents between 18 and 49 years of age and almost two-thirds between 50 and 64 have home broadband service, less than half of those aged 65 and older

[101] Davidson et al. 2012.
[102] Connected Tennessee 2015.
[103] Federal Communications Commission 2010a.
[104] Connected Nation 2011; US Department of Commerce, National Telecommunications and Information Administration 2011; Zickuhr 2013; US Department of Commerce, National Telecommunications and Information Administration 2014; and Horrigan and Duggan 2015.

do. The same survey found that approximately nine in ten respondents with household incomes above $75,000 per year have home broadband, compared with four in five of those with annual incomes between $50,000 and $75,000 and nearly two-thirds of those with annual incomes between $20,000 and $50,000. But of respondents with household incomes below $20,000 per year, less than half have home broadband service. Similarly, the survey found that respondents with less schooling and those who are African American or Hispanic are less likely to have home broadband than those with college degrees or those who are white.[105]

Demographic data alone, however, do not explain why individuals in these groups are less likely to adopt broadband.

For those with access to broadband, the most common reasons for not adopting it are perceived lack of value and the cost of service and devices.

Cost and factors that affect value, such as perception, relevance, and user skills, are most likely to determine whether individuals who have access to broadband adopt service. The National Telecommunications and Information Administration's (NTIA) Broadband Adoption Toolkit says that

> research has found that there are a number of barriers that keep individuals from adopting broadband . . . :
>
> **Access and Availability:** While not the most prevalent factor, lack of access and availability still remain a key barrier to adoption. Access is a barrier for households in areas where high-speed Internet is not available, especially in rural areas of the country. According to NTIA's 2011 Digital Nation report, 40 percent of rural Americans did not subscribe to broadband at home, with 9.4 percent (compared to 1 percent in urban areas) noting a lack of broadband availability as the primary barrier to adoption.
>
> **Cost:** Rural and urban populations alike cite the high cost of broadband subscriptions as a reason for non-adoption. Non-adopters also may have concerns about the confusing and unpredictable nature of broadband subscription costs, or find that the cost of purchasing and maintaining a computer is a barrier to connecting to broadband service.

[105] Horrigan and Duggan 2015.

Perception: Many non-adopters have not experienced the benefits of being online and are apprehensive about the Internet. They perceive the Internet as unknown and dangerous, potentially compromising privacy, the safety of their children, and their financial security. They may not be aware of opportunities to learn how to protect themselves on the Internet or to be part of a social network that includes people with the expertise to help them.

Relevance: Non-adopters often do not believe that broadband Internet is relevant to their lives. These Americans are used to performing tasks and accessing services without using the Internet, and they do not think that there is anything on the Internet that would improve or enhance their lives.

Skills: Many non-adopters, especially older, less-educated, and lower-income Americans, do not have the digital literacy skills needed to use online tools and services effectively. They may own computers and/or have broadband available to them, but they are not comfortable, confident users.[106]

Access and availability will be discussed below. But for those who don't subscribe to service despite having access to it, factors that affect value and cost are the primary barriers to adoption.

Value: Perception, Relevance, and Skills

The last three of the NTIA's listed factors—perception, relevance, and skill—all affect whether individuals value broadband enough to adopt service. Approximately two-thirds of respondents in a 2013 Pew survey cited lack of relevance, lack of skill, or perceived risks as their primary reason for not using the internet.[107] Similarly, almost half of those who did not use the internet at home said either that they did not need it or were not interested in it, according to NTIA's analysis of the US Department of Commerce's October 2012 Current Population Survey.[108]

Lack of perceived value tends to be more important than cost as a barrier to home broadband adoption for so-called "hard-to-reach" non-adopters—

[106] US Department of Commerce, National Telecommunications and Information Administration 2013.
[107] Zickuhr 2013.
[108] US Department of Commerce, National Telecommunications and Information Administration 2014.

those who have never had home broadband before and who have no interest in getting it. According to Pew's 2015 broadband survey,

> the "hard-to-reach" are:
>
> **less educated:** Just 8% of the "hard-to-reach" have a college degree, compared with 14% of other non-adopters;
>
> **older:** 39% of the "hard-to-reach" are age 65 or older, compared with 19% for remaining non-adopters; [and]
>
> **less connected to technology:** Just 44% of the "hard-to-reach" are internet users, and just 29% have smartphones; the figures for other non-adopters are 72% and 53% respectively.
>
> The other notable characteristic of the "hard-to-reach" is that they are *less* likely to cite the monthly access fee as their most important reason for not having service.[109]

Perceived risk is an important barrier to broadband adoption for some businesses as well. Nearly 75% of businesses that chose to respond to ECD's broadband survey said security concerns were either a very important or somewhat important barrier to broadband adoption, while over 60% of businesses said the same about privacy concerns.[110]

Cost: Service and Devices

In addition to value, both the cost of service and the cost of devices are often cited as reasons for not using or subscribing to broadband. Pew's 2015 survey of broadband adoption found that 43% of respondents without broadband at home said either that the service or a computer was too expensive.[111] Cost is also a significant barrier to internet use in general, not just home broadband subscriptions. Pew's 2013 study found that almost 20% of respondents who did not use the internet cited either the cost of service or their lack of a computer as their primary reason.[112]

Cost, unsurprisingly, is particularly important for those with lower incomes. The NTIA's analysis of the October 2012 Current Population Survey found

[109] Horrigan and Duggan 2015.
[110] Tennessee Department of Economic and Community Development 2016.
[111] Horrigan and Duggan 2015.
[112] Zickuhr 2013.

> an inverse relationship between family income and the incidence of responding households to reply that high Internet costs prevented them from getting online in their homes. . . . In 2012, non-adopting households earning less than $25,000 annually were the income group most concerned about the cost of home Internet service, but significantly, they were also the least likely to say they had no interest or need for such service.[113]

Families with children eligible for free or reduced school lunch are also more likely than other families to say that cost is the primary barrier to computer ownership or broadband service, according to a 2011 survey by Connected Nation.[114] Moreover, 81% of respondents with incomes below $30,000 per year who chose to participate in ECD's broadband survey said that affordability was a major concern when selecting an internet service provider.[115]

Digital literacy training, service discounts, and device discounts all encourage broadband adoption.

There is no one broadband adoption program that overcomes all of the barriers to potential users. According to the NTIA in its Broadband Adoption Toolkit,

> these barriers are cross-cutting, and many individuals cite more than one barrier as a reason for non-adoption. For example, parents may have the skills and the resources to have broadband at home, but may worry that their children are not safe when online. Others may be more comfortable paying bills manually or in person and worry about whether their personal data will be protected if they manage finances online. Older individuals may be intimidated by technology and not realize that the Internet could provide a way to manage prescriptions or health information from their homes. An urban resident may have broadband available and a computer at home, but be unable to afford a monthly broadband subscription. Each of these concerns deters Americans from becoming adopters.[116]

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[113] US Department of Commerce, National Telecommunications and Information Administration 2014.
[114] Connected Nation 2011.
[115] Tennessee Department of Economic and Community Development 2016.
[116] US Department of Commerce, National Telecommunications and Information Administration 2013.

Assessing the success of many adoption programs is difficult because the number of participants who go on to adopt or maintain service after completing a program is not always available. Too often this has left stakeholders "flying blind when it comes to understanding best practices to improve broadband adoption," according to John Horrigan, a senior researcher at the Pew Research Center.[117]

The NTIA, however, outlines general guidelines for successful broadband adoption programs in its toolkit. These guidelines are based on outcomes from over 100 adoption programs that received more than $450 million in total funding through the American Recovery and Reinvestment Act.[118] According to the NTIA,

> the role of broadband adoption programs goes beyond simply stating the benefits of broadband or assuming that people will want to get online. Adoption programs need to meet people where they are, encourage them, and show them how they can safely use the Internet to improve their lives.[119]

Successful programs—those that meet people where they are—address barriers to broadband adoption through training and discounts for service and devices. In addition to general awareness and community outreach, the NTIA says the key elements of these programs include:

> **Home Computer & Broadband Service:** The costs of computer ownership and home broadband service can be prohibitive for some community members. Successful broadband adoption projects use multiple strategies, such as discounts and incentives, to make owning a computer and using a broadband connection less expensive and less confusing.
>
> **Training: Planning & Delivery:** The most successful broadband adoption programs provide some form of digital literacy training. Including training as a tactic is not required, but the majority of the barriers to adoption can be addressed through some sort of training. Training is most effective when it is tailored to address the specific needs of the target audience.

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[117] Horrigan 2012.
[118] US Department of Commerce, National Telecommunications and Information Administration 2013.
[119] Ibid.

Training: Curriculum & Relevant Content: Broadband adoption programs often involve selecting or developing some form of digital literacy curriculum. Depending on the target audience, the curricula could focus on basic skills (e.g., keyboarding or using a mouse) or more advanced skills (e.g., evaluating online information or creating digital media such as movies or music). Curricula and digital literacy tools should build skills that enable students to improve their lives.[120]

Deciding which program to implement—what training to offer, if any, and whether to provide discounts for service and devices—depends on the

- goals of the program,
- barriers to adoption in the community, and
- needs and preferences of the population that will be served.[121]

Programs intended to increase broadband adoption among older adults, for example, might focus on accessing state and federal benefits as well as resources for health, social engagement, and financial security because seniors "are poised to benefit most immediately from these types of services," according to a study by New York Law School professors Charles Davidson and Michael Santorelli.[122] Meanwhile, low-income residents in rural areas might find it inconvenient or even cost-prohibitive to travel to in-person digital literacy trainings. And in some cases, access to free or low-cost devices is at least if not more important for participants in adoption programs than either training or discounted service.[123]

Successful broadband adoption programs are tailored to local needs.

Broadband adoption programs depend on identifying the specific barriers of non-adopters at the community level. The Metropolitan Government of Nashville and Davidson County began investigating ways to increase access and adoption after a 2012 survey found that 44% of Nashville's public school students—approximately 35,000 of 80,000 students—either didn't have access to a computer or broadband at home or didn't think they would benefit from having them. To address these barriers and improve adoption among families with school children, Metro-Nashville launched a pilot program called Anytime Access for All at three of its schools in the 2015-16 school year. Families who participate in the program receive three hours of digital literacy training through Nashville Public Library, schools, and non-profit partners as well as low-cost broadband service

[120] Ibid.
[121] Ibid.
[122] Davidson et al. 2012.
[123] North Carolina Department of Commerce 2015.

from local providers. These families also receive the option to purchase a broadband enabled device for $25 through a partnership with the Community Foundation of Middle Tennessee, which continues to bring on new partners and resources to provide low-cost internet access and devices to those living under the poverty level. The partnership initially included Metro-Nashville, Vanderbilt University, Dell Computers, and ER2, a company that recycles used electronics. Approximately 140 families have completed the program along with 100 additional families who have participated through the Metropolitan Housing Development Authority's Connect Home project. The Anytime Access for All program cost approximately $145 per family in its first year and is managed through the Community Foundation of Middle Tennessee's Digital Inclusion Fund. Various other non-profit organizations who have demonstrated an ability to assist with technology training for economically challenged individuals and families are helping expand the program.[124]

Similar programs in Boston, Massachusetts, Chattanooga, and New York City have also been successful. In Boston, the Tech Goes Home program focuses on increasing broadband adoption among low-income populations.[125] Participants have the opportunity to purchase a new device for $50 and receive assistance finding low-cost service options after completing 15 hours of digital literacy training provided through schools or community organizations.[126] The program has provided training to more than 20,000 people since 2010 of which 90% had home broadband service one year after completing the program, compared with only 66% before.[127]

Chattanooga also began using the Tech Goes Home program in 2015. Much like in Boston, participants complete 15 hours of training offered through schools, libraries, churches, and community centers after which they receive assistance finding low-cost broadband service. Those who complete the training also have the option to purchase a new device for $50 if they have

- annual income below $30,000, with exceptions for large families;
- a disability or a family member with a disability;
- been unemployed or underemployed for an extended period;
- don't have a desktop or laptop computer at home; or
- are an English language learner.[128]

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[124] Email from Jackie Shrago, fund support for digital inclusion, Community Foundation of Middle Tennessee, November 16, 2016; panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016; and Community Foundation of Middle Tennessee 2016.
[125] Tech Goes Home 2016a.
[126] Tech Goes Home 2016c.
[127] Tech Goes Home 2016b.
[128] Tech Goes Home Chattanooga 2016; and email from Kelly McCarthy, program director, Tech Goes Home Chattanooga, January 11, 2017.

Follow-up surveys with participants show that 91% subscribe to broadband six months after completing the program, compared with 64% before starting the program. The program cost approximately $330 per participant over the last two years, though costs have been decreasing. In fall 2016, the average cost per participant was $150. Tech Goes Home Chattanooga is operated in conjunction with the Enterprise Center, an organization dedicated to establishing Chattanooga as a hub of innovation.[129]

In New York City, the non-profit organization PowerMyLearning partners with public schools to increase broadband adoption among families with schoolchildren. PowerMyLearning provides participating families with a free, refurbished computer and 24/7 technical support, and it offers information about low-cost broadband service. Participating families are also required to attend a four-hour training session on computer and internet skills and the benefits of broadband for education.[130] From 2010 through 2012, PowerMyLearning's program resulted in more than 7,500 families in the city adopting service who hadn't had it before. Overall, 93% of participating families had broadband three months after completing training, compared with only 50% before. The program costs between $400 and $700 per student depending on hardware and software donations.[131]

In Ohio, the Every Citizen Online program developed by Connect Ohio, that state's affiliate of Connected Nation, partnered with 281 libraries to offer digital literacy training. Participants received six hours of training on computers and the benefits of internet use. Depending on their location, participants were also offered free service installation, discounts on other initial subscription costs, low-cost refurbished computers, or monthly service subsidies. More than 20,000 people had completed training as of March 2012 and almost 1,200 computers had been distributed. A survey of those who completed the program found that 64% said they would probably subscribe to service within the next year as a result of the training they received.[132]

Advertising campaigns to raise awareness of broadband's benefits can be effective when they are tailored to the needs of specific communities. According to the NTIA,

> the City of Chicago, with the Local Initiative Support Corporation (LISC), . . . worked to increase broadband adoption in five low-income neighborhoods in Chicago.

[129] Telephone interview with Kelly McCarthy, program director, Tech Goes Home Chattanooga, January 4, 2017; Flessner 2015; and The Enterprise Center "About Us."
[130] New York City Comptroller's Office 2013; and US Department of Commerce, National Telecommunications and Information Administration 2013.
[131] New York City Comptroller's Office 2013; and PowerMyLearning 2016.
[132] Lane and McGovern "Every Citizen Online: A New Model for Digital Inclusion."

> LISC and its tech organizers engaged a marketing firm to develop an awareness campaign that used personal stories to illustrate the advantages of broadband use. Each neighborhood included different demographic groups, from Hispanic immigrants in Pilsen to African Americans in Englewood. The goal of the campaign was to create a series of ads that could be tailored to each neighborhood's needs. The firm met with leaders of community agencies, listened to their ideas, and proposed designs that featured individuals from the targeted demographic groups sharing their broadband "success stories." This method tapped into relevant themes and also gathered real examples from the community. LISC placed ads on buses and rail, as well as on brochures and postcards for door-to-door outreach.
>
> As a result of this awareness campaign, other outreach efforts, and training programs, the City observed increases in broadband adoption. A citywide study showed that more than 32,000 households obtained broadband subscriptions, and that residents in the five targeted low-income neighborhoods had increases in subscribership that were 15 percent higher than in similar neighborhoods.[133]

Pilot programs focused on low-income populations in Illinois and North Carolina show that discounts for service and devices can encourage adoption among groups for whom cost is a major barrier. The Illinois program offered all participants a $60 credit toward service installation, a $30 per month discount on broadband service, and the option to purchase a refurbished desktop at a discount from Computer Banc, a non-profit United Way member agency located in Illinois that provides discounted computers to at-risk populations priced at cost.[134] Sixty-three of 153 participants were also offered digital literacy training. Almost all participants earned less than $30,000 per year, and 73% had never had home broadband before. Of those who had never had home broadband before, half said that it was too expensive, and for those who had home broadband in the past, 78% cancelled it because it cost too much. The results of the pilot program show that providing discounted service and devices can not only encourage low-income populations to sign up for service but also retain it even after subsidies end. Almost 90% of participants maintained broadband service throughout the 12 months when they received service

[133] US Department of Commerce, National Telecommunications and Information Administration 2013.
[134] Buss 2015; and Computer Banc "Our Mission."

discounts, and more importantly, 66% of subscribers still had service two months after the discounts ended regardless of whether they had received digital literacy training.[135]

In North Carolina, the Linking Internet to Economically Underprivileged People (LITE-UP) pilot program demonstrates that eliminating the cost of devices can encourage low-income populations to adopt broadband. Participants included 179 low-income households, and each received a free desktop computer and free technical support. Participants were randomly assigned to receive a 100% service discount, a 50% service discount, or no discount, and within each of these groups, half of participants were offered digital literacy training. Eighty-five percent of households signed up for broadband during the program, and 71% still had service after it ended. Whether a participant received discounted service, however, did not have a statistically significant effect on whether they signed up for service, while those offered digital literacy training were actually less likely to sign up for service.[136] LITE-UP's analysis found that

> computers or some form of access device, may be the first and most important investment in broadband adoption. Providing a home computer and helping establish home Internet access appears to have had more impact than subsidies and/or digital literacy training. Computers were the leading enticement for participation (76%), followed by Internet access (54%) and digital literacy training (39%).[137]

In Tennessee, the Computers4Kids program has awarded more than 5,000 computers to youth in need across the state, including almost 2,900 young Tennesseans aging out of the foster system. Managed by Connected Tennessee, the program provided support to all 76 Boys & Girls Clubs in the state, including over 90,000 hours of computer training.[138] Connected Tennessee has also partnered with communities to develop broadband technology plans that focus on improving adoption and use in addition to coverage.[139]

The Tennessee Department of Economic and Community Development (ECD) recommends developing "specific initiatives that target key constituencies that are either not using or are under-utilizing the Internet,"[140] in a report accompanying the results of its 2016 broadband

[135] Buss 2015.
[136] North Carolina Department of Commerce 2015.
[137] Ibid.
[138] Ramage 2016.
[139] Clarksville-Montgomery County Technology Planning Team and Connected Tennessee 2015.
[140] Tennessee Department of Economic and Community Development 2016.

survey. According to ECD, "driving utilization of the Internet among target populations requires increasing awareness and appreciation of the potential benefits of using the Internet, as well as acquiring specific skills," and the development of adoption initiatives, particularly for businesses, is "best done within a local or regional context."[141]

Community anchor institutions and economic development agencies can play an important role in facilitating these adoption initiatives. According to ECD,

> economic development agencies are well placed to help businesses increase their Internet utilization and maximize the potential benefits. Many of these agencies already have connections with individual businesses and provide some forms of skills development, mentoring and support. Similarly, libraries have existing profile and capacity to reach the general public, especially children and seniors. Libraries can, with additional resources to expand their awareness and education efforts, focus on people with low or no Internet skills. Libraries also are a key source of free access to the Internet for school-aged children and lower income individuals.[142]

Tennessee already has several public and private resources available for improving digital literacy and reducing the cost of devices and service.

Communities have several existing resources that can be incorporated into local broadband adoption plans. Libraries and schools provide access to training as well as service and devices for those who cannot afford their own. Both libraries and schools receive financial support through the federal government's E-Rate program, which subsidizes the cost of broadband service and infrastructure. Service discounts are also available directly to low-income individuals and families from internet providers, and the federal government expanded its telephone service discount program for low-income populations to include broadband in December 2016.

Libraries

Tennessee's local library system is positioned to help residents improve their digital literacy skills and learn about the ways they can benefit from broadband. When libraries offer digital literacy classes, people come in

[141] Ibid.
[142] Ibid.

large numbers. The Tennessee State Library and Archives (TSLA), in partnership with ECD and the US Department of Agriculture, provided 60 hours of training in each of 70 libraries from June 2010 to June 2012, and more than 13,000 people attended. The state provided $2,400 in funding to each library to pay instructors for offering the training sessions, approximately $40 per class.[143]

TSLA continues to encourage the state's local libraries to offer digital literacy training regularly to patrons. TSLA has adopted technology services guidelines that call for all libraries serving at least 5,000 patrons to offer meeting space and devices to community organizations for digital literacy training. Libraries are also encouraged to provide digital literacy training several times a year depending on size, ranging from once per quarter for smaller libraries to twice per month for larger libraries. See appendix H.

Tennessee's libraries are making the most of the limited resources they have available for digital literacy training. Although the state's technology services guidelines are voluntary, approximately 75% of libraries serving at least 5,000 patrons currently meet them, according to TSLA.[144] But libraries are limited by equipment, staff time, and staff expertise from consistently providing computer classes. According to TSLA, free public classes taught by qualified trainers would be widely used and very popular with the public.[145] Ensuring that all libraries meet TSLA's guidelines would cost approximately $144,640 per year.[146]

Further, 18 libraries throughout the state are addressing the affordability gap in their communities by lending hotspot devices that allow patrons to access wireless broadband. These programs provide patrons with service when they most need it, such as working on a research project for school or after they have already exceeded data caps for their own mobile wireless service. Libraries report very strong demand for the devices, and waiting lists are common, according to TSLA.[147] Although the devices initially could cost approximately $130 each,[148] providers are now offering

[143] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016; and email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 14, 2016.
[144] Panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016.
[145] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016.
[146] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 14, 2016.
[147] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016.
[148] Telephone interview with Jennifer Urban, circulation director, Spring Hill Public Library, October 26, 2016.

them to libraries at no cost.[149] Broadband service for the devices costs approximately $32 per device per month[150] and can be shut off remotely if devices are not returned.[151] If hotspot lending programs were expanded, a ratio of one device for every 1,500 residents would be reasonable, according to TSLA.[152] It would cost approximately $1.6 million annually to deploy enough hotspots at libraries statewide to achieve this ratio based on the state's population in the 2010 Census.

Schools

Local schools are another existing resource for improving digital literacy skills and access to devices. The Tennessee Department of Education is working to improve opportunities for digital literacy training both inside and outside the classroom by purchasing a statewide license for Microsoft's Imagine Academy program. Imagine Academy includes several online courses that provide instruction on using the Microsoft Office suite of products as well as software development. Several districts already subscribe to the program individually, but the statewide license will make Imagine Academy's resources available to every high school student in Tennessee at a cost to the state of approximately $440,000 per year. The program could be available as early as spring 2017.[153]

Schools can help increase the affordability of broadband adoption by providing access to devices. Moreover, as instruction and assignments move online, the need for every student in a classroom to have a broadband enabled device increases.[154] But purchasing new or replacing existing devices has traditionally been cost prohibitive for schools. To overcome this barrier, the Tennessee Department of Education is developing a purchasing model in partnership with the Tennessee Comptroller of the Treasury that will allow schools to enter three-year contracts with approved vendors to lease devices for approximately $5 per student per month. The devices will be replaced every three years. Vendors must agree to the program's basic criteria regarding leasing and replacing devices to be approved, and several leading vendors have already expressed interest in participating. Districts that choose to work with an approved vendor will not be subject

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[149] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016; and telephone interview with Jennifer Urban, circulation director, Spring Hill Public Library, October 26, 2016.
[150] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016.
[151] Telephone interview with Jennifer Urban, circulation director, Spring Hill Public Library, October 26, 2016.
[152] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, December 30, 2016.
[153] Interview with Cliff Lloyd, chief information officer, Tennessee Department of Education, November 4, 2016; and panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016.
[154] Fox and Jones 2016.

to the state restriction against making multiyear budget commitments. The program will not only allow districts to obtain more devices but also replace them regularly at lower overall costs than purchasing devices outright every three years. More importantly, the devices will be available to students to take home to complete assignments and other coursework.[155]

Discount Programs

Several broadband discount programs already exist for improving access to affordable service. Some of these programs provide service discounts to residential customers and include both federal subsidies and provider-led programs. The federal E-Rate program, in contrast, provides service subsidies to schools and libraries, which can serve as resources for increasing access to broadband for individuals and families who cannot otherwise afford it.

E-Rate Program

The federal E-Rate program covers up to 90% of the cost of broadband service for schools and libraries. The size of the subsidy varies depending both on whether a school or library is located in an urban or rural area and on the level of poverty in the community a school or library serves.[156] Schools in Tennessee receive a subsidy of 86% on average through E-Rate, according to the Tennessee Department of Education.[157] Similarly, many libraries in Tennessee receive subsidies of between 80% and 90%, according to TSLA.[158] Schools and libraries must select their service providers through competitive bidding processes to qualify for E-Rate.[159] The program relies on proceeds from the Universal Service Fund, which is funded by a tax on wired and wireless telephone service.[160]

While every school and library in the state has internet access, not all have broadband quality service. Even with E-Rate support, cost is still a barrier, especially for some libraries. Of 109 libraries in the state's regional library system that have access to broadband that meets the American Library Association's standard of at least 100 megabits per second but don't subscribe to it, 82 say they cannot afford the service, according to TSLA.[161]

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[155] Interview with Cliff Lloyd, chief information officer, Tennessee Department of Education, November 4, 2016; and panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016.
[156] Federal Communications Commission 2016e.
[157] Panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016.
[158] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016.
[159] 47 Code of Federal Regulations 54.503(a).
[160] Federal Communications Commission 2016e; and 47 Code of Federal Regulations 54.706.
[161] Email from Charles Sherrill, state librarian and archivist, Tennessee State Library and Archives, November 4, 2016.

Other libraries share their connections and don't have control over what service is chosen, while some report that local governments hinder their ability to subscribe to higher-capacity connections.[162]

Approximately 50 school districts were denied E-Rate funding in 2015 by the contractor that manages the program for the FCC because of problems with their competitive bidding processes, according to the Tennessee Department of Education.[163] The Department worked with these school districts to comply with FCC guidelines and developed a statewide consortium for the competitive bidding process that any district could take part in. In 2016, all districts in the state qualified for E-Rate funds, and the statewide consortium helped reduce the cost of broadband for schools in Tennessee to $52 million total before applying the E-Rate discounts compared with $72 million in 2015.[164]

Healthcare Connect Fund

Similar to the E-Rate program, the federal Healthcare Connect Fund (HCF) subsidizes 65% of the cost of broadband infrastructure and service for public and non-profit healthcare providers in rural areas.[165] Rural healthcare providers rely on this federal funding to defray the costs of broadband service necessary for telemedicine programs and managing electronic health records.[166] Public and non-profit healthcare providers in urban areas are also eligible for the program if they apply as part of consortia in which the majority of providers are rural. The HCF relies on proceeds from the Universal Service Fund. Annual funding for the entire program is capped at $400 million per year, but this has never been reached.[167]

Provider-Led Programs

Some broadband providers already offer their own discount programs. Eligibility for these programs varies by provider but is typically restricted to households who have not subscribed to service within several months, have no outstanding debt with the provider, and who are also eligible for certain government benefits. Participants typically receive broadband that meets the minimum 10/1 requirement for approximately $10 per month.[168]

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[162] Tennessee State Library and Archives 2016.
[163] Panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016; and telephone interview with Cliff Lloyd, chief information officer, Tennessee Department of Education, October 8, 2015.
[164] Panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016.
[165] Federal Communications Commission 2012.
[166] Panel discussion of issues related to broadband access, adoption, and incentives, TACIR, August 31, 2016.
[167] Federal Communications Commission 2016d.
[168] Comcast "Terms and Conditions: Internet Essentials"; and AT&T 2016a.

For example, Comcast's Internet Essentials program provides 10/1 service for $9.95 per month to families in Comcast's service area who have

- at least one child living with them who is eligible for free or reduced school lunches,
- not subscribed to Comcast internet services within the past 90 days, and
- no overdue bills or unreturned equipment with Comcast in the last year.[169]

Comcast has expanded access to Internet Essentials in some communities. In Nashville as well as Seattle, Philadelphia, and Miami-Dade County, Internet Essentials is available to all public housing residents who meet the restrictions on debt and prior service.[170] In Philadelphia, Internet Essentials is also available to residents who meet the restrictions on debt and prior service who currently receive federal assistance through a variety of programs including Medicaid, Head Start, Supplemental Nutrition Assistance Program, Supplemental Security Income, Temporary Assistance to Needy Families, the Low-Income Home Energy Assistance Program, Emergency Aid to the Elderly, Disabled, and Children, Bureau of Indian Affairs General Assistance, Tribally-Administered Temporary Assistance for Needy Families, and Food Distribution Program on Indian Reservations. In several other communities, Internet Essentials is available to residents who are at least 62 years old, meet the restrictions on debt and prior service, and who receive aid through a variety of state or federal programs. In Illinois and Colorado, community college students who meet the restrictions on debt and prior service and who have received a Pell Grant are eligible as well.[171]

AT&T's low-income discount program, Access from AT&T, provides up to 10/1 service for $10 per month to households in AT&T's service area with

- at least one resident who is eligible for the Supplemental Nutrition Assistance Program (SNAP) and
- no outstanding debt to AT&T for either
  - » fixed internet service (not mobile) in the last six months or
  - » the Access from AT&T program.

In California, households are also eligible for Access from AT&T if at least one member is eligible for Supplemental Security Income and the household meets the outstanding debt requirements that apply to all participants in Access from AT&T. In parts of AT&T's service area where

[169] Comcast "Terms and Conditions: Internet Essentials."
[170] Comcast 2016b; and Comcast "Terms and Conditions: Internet Essentials."
[171] Comcast "Terms and Conditions: Internet Essentials."

10/1 is not available, program participants receive the largest capacity offered. For services of 3/1 or less, the price is reduced to $5 per month.[172]

CenturyLink also offers its Internet Basics program for $9.95 per month for the first year and $14.95 per month for the second year, though its maximum capacity is only 1.5 megabits per second. Internet Basics is available to individuals in CenturyLink's service area who have

- not subscribed to CenturyLink internet service,
- no overdue bills or unreturned equipment with CenturyLink, and who are
- eligible for the Lifeline program.[173]

Providers also offer digital literacy training and low-cost devices to program participants. Comcast and CenturyLink offer participants access to training programs at no additional cost, and both offer participants the opportunity to purchase a device for $150.[174] AT&T has a variety of digital literacy resources available on its Digital You website,[175] where it also provides information on obtaining discounted devices from EveryoneOn, a national non-profit that provides access to low-cost devices, service, and digital literacy training.[176]

Lifeline Program

The FCC expanded its Lifeline program from mobile and wireline telephone service to include broadband as of December 2016. Lifeline initially offered discounts on landline telephone service in the 1980s but was expanded in 2008 to include mobile phones.[177] Like E-Rate, Lifeline is supported by proceeds from the Universal Service Fund's tax on wired and wireless telephone service.[178] Participants receive a $9.25 per month discount but only for service with a capacity of at least 10/1 and a data cap of at least 150 gigabytes per month for fixed broadband. In areas where a provider does not offer service of at least 10/1, fixed service of at least 4/1 is also eligible for the Lifeline program.[179] For mobile broadband, participants will receive a $9.25 per month discount for service of at least 3G[180]—corresponding to expected capacities of up to 3/1, according to one major provider.[181] The minimum data cap eligible for Lifeline for mobile broadband will be 0.5

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[172] AT&T 2016a.
[173] CenturyLink 2016.
[174] Comcast "Terms and Conditions: Internet Essentials"; and CenturyLink "Stay Connected with Affordable Internet."
[175] AT&T "Digital You."
[176] AT&T "Digital You: Low-Cost Home Internet"; and EveryoneOn 2016.
[177] Federal Communications Commission 2016i.
[178] Federal Communications Commission 2016m.
[179] Federal Communications Commission 2016i.
[180] Ibid.
[181] AT&T 2016c.

gigabytes per month until December 2017. This minimum data cap for mobile broadband under Lifeline will rise to one gigabyte per month until December 2018 and two gigabytes per month until December 2019, after which it will be set at 70% of the average amount of mobile data used per household in the US, which would be equal to two gigabytes per month if calculated using the current per household average.[182]

Eligibility is restricted to households that make no more than 135% of the federal government's poverty guidelines or households with members eligible for other federal or state assistance programs that as of December 2, 2016, include the

- Supplemental Nutrition Assistance Program (SNAP)—food stamps,
- Medicaid,
- Supplemental Security Income (SSI),
- Federal Public Housing Assistance, and
- Veterans Pension and Survivors Benefit.[183]

Those who reside on tribal lands are eligible if they also participate in

- Bureau of Indian Affairs General Assistance,
- Head Start but only households meeting the income qualifying standard,
- Tribal Temporary Assistance for Needy Families (Tribal TANF), or
- Food Distribution Program on Indian Reservations.[184]

Because anyone eligible for these federal and state programs is automatically eligible for Lifeline, providing administrative assistance through existing state agencies to help eligible individuals sign up for Lifeline service could increase participation in the program and expand broadband adoption among low-income communities.

The federal government does not offer device discounts under the Lifeline program. While some providers have offered free devices to participants in the program when it applied to telephone service alone, it is too early to tell whether providers will offer free or discounted broadband devices to participants now that the program has been expanded to include broadband service.[185]

[182] Federal Communications Commission 2016i.
[183] Universal Service Administrative Company 2016.
[184] Ibid.
[185] Email from Jeff Van Dyke, vice president, government affairs, AT&T Tennessee, December 22, 2016.

Expanding coverage requires creating incentives and removing barriers for providers.

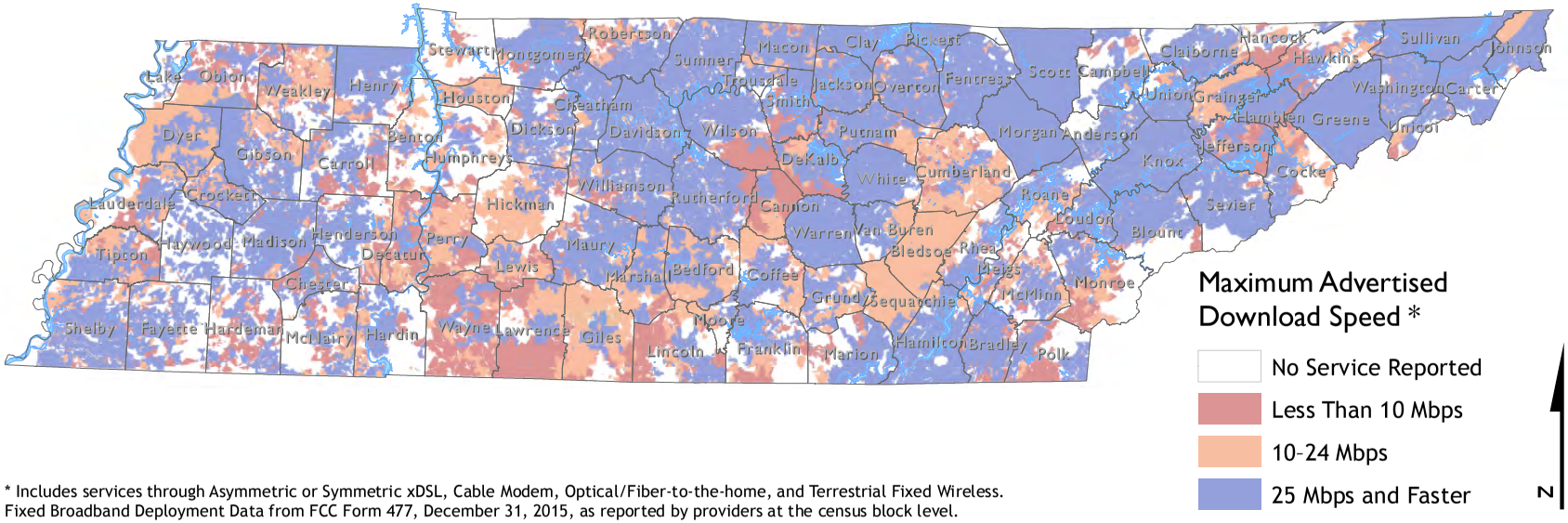
Filling remaining coverage gaps will help ensure that all Tennesseans are able to take advantage of broadband's benefits. While providers have been expanding coverage, there are still communities in Tennessee that lack access to broadband of at least 25/3 or even 10/1. These areas tend to have lower population densities and therefore fewer potential subscribers per mile to cover the costs of expanding service. Increasing overall rates of broadband adoption can help providers justify new investments in unserved and underserved areas, but encouraging adoption alone is unlikely to solve the state's coverage issues. The federal government has created incentives for providers to expand coverage in unserved and underserved areas through grant programs like the Connect America Fund. Several states have similar grant programs, and others offer tax incentives tied to the expansion of coverage. Some state and local governments have also reduced regulatory barriers for broadband providers.

Access to broadband lags in sparsely populated rural areas.

Most Tennesseans live in census blocks where providers report offering wireline or fixed wireless coverage of at least 10/1 if not 25/3. Approximately 93% of the state's population is located in census blocks where at least one provider reported offering service of 10/1 or better as of December 2015. Similarly, 89% live in census blocks where at least one provider reported offering service of 25/3 or better.[186] These percentages have both increased in recent years. As of December 2013, 89% of Tennesseans lived in census blocks where at least one provider reported offering 10/1 or better, and 82% lived in census blocks where at least one provider reported offering 25/3 or better.[187] See map 1 (reposted) and appendix F.

[186] TACIR staff calculations using FCC Form 477 data reported as of December 31, 2015, and population data from 2010 census.
[187] Federal Communications Commission 2015d.

Map 1. Maximum Advertised Download Speeds Reported by Providers in each Census Block in Tennessee as of December 2015.



* Includes services through Asymmetric or Symmetric xDSL, Cable Modem, Optical/Fiber-to-the-home, and Terrestrial Fixed Wireless.
Fixed Broadband Deployment Data from FCC Form 477, December 31, 2015, as reported by providers at the census block level.

But the increasing overall percentage of Tennesseans who have access to broadband masks coverage disparities between urban and rural areas. According to the FCC, 98% of Tennesseans in urban areas live in census blocks where at least one provider reported offering service of 25/3 or better as of December 2014, compared with just 66% in rural areas.[188] This urban-rural coverage divide is a result of the economics of building and maintaining broadband networks, which favor densely populated communities. According to the US Government Accountability Office (GAO) in a 2014 report on policies for expanding broadband coverage,

> unserved and underserved areas tend to have conditions that increase the cost of constructing and maintaining broadband networks. These conditions include low populations who might also be widely dispersed and in remote areas that might have challenging terrain, such as mountains, that increase construction costs. The choice of broadband technology and the ability to use or extend existing infrastructure also affects the costs of constructing and maintaining broadband networks. Certain technologies like cable and fiber, which must be buried underground or placed on raised poles, could be more expensive to deploy in remote areas than wireless technologies, such as cellular towers.[189]

The GAO summarizes the effect of low population density and difficult terrain on deployment in rural areas later in the same report, saying that

> as noted above, remote areas generally have high costs to deploy broadband due to the expense of deploying technologies over long distances and potentially difficult terrain to often relatively few potential subscribers. For these reasons, stakeholders told us that being able to cover costs with potential revenues and thus make a return on investment is a key issue to deploying broadband in unserved and underserved areas.[190]

The barriers to expanding coverage in unserved and underserved rural areas are not unique to broadband. According to the Tennessee Electric Cooperative Association,

> for the many years that rural electrification eluded the United States, there was little argument about what it

[188] Federal Communications Commission 2016h.
[189] US Government Accountability Office 2014b.
[190] Ibid.

> would cost to build-out the electric grid into the far reaches of the countryside. . . .
>
> Decisions to expand electric service and the resulting large capital expenditures were represented by a fairly simple equation and decision:
>
> - Total cost of construction (capital cost) ÷ *total number of customers* = Cost-per-customer
> - If cost-per-customer over a *specified period of time* was sufficiently less than total revenue (profit margin), service would be extended
>
> While there were other cost factors inherent in the equation . . . the primary variables were total number of customers and the required payback time (italicized above). In other words, customer density and required payback time were the key factors in the decision to deploy new lines.[191]

Much like electric utilities in the 20th century, providers often can't make a business case for investing in broadband infrastructure in rural areas. In a different 2014 report on policies for expanding broadband coverage, the GAO says that

> the provision of broadband Internet networks and services in the United States is generally privately financed. Rural areas, though, can have conditions that increase the cost of broadband deployment—such as remote areas with challenging terrain like mountains, which increase construction costs—or conditions that make it difficult to recoup deployment costs—such as relatively low population densities and incomes. These conditions make it less likely that a private service provider will build out or maintain a broadband network. Low population density can mean fewer potential subscribers, and low-income populations are less likely to use broadband.[192]

Unsurprisingly, the census blocks in Tennessee where no provider reported offering broadband of at least 10/1 or 25/3 as of December 2015 have lower housing unit densities on average than those where service was reported.

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[191] Memorandum from Tennessee Electric Cooperative Association to TACIR, October 21, 2015, https://www.tn.gov/assets/entities/tacir/attachments/2015OctoberTab3BB_TECA.pdf.
[192] US Government Accountability Office 2014a.

While the average housing unit density of blocks without access to 10/1 is approximately 17 units per square mile, the average density for blocks where providers reported offering at least 10/1 but less than 25/3 is 23 units per square mile. Moreover, the average housing unit density of blocks where providers reported offering at least 25/3 is 127 units per square mile. The likelihood that a census block will have service of at least 10/1 or 25/3 reported for it also rises as housing unit density increases. While only 51% of the 10% of census blocks with the lowest housing densities have access to service of at least 10/1, over 90% of the highest density census blocks do.[193] See figure 1.

Figure 1. Percentage of Census Blocks with Access to Broadband as of December 2015 by Housing Unit Density Decile

Source: TACIR staff calculations based on December 2015 Form 477 data and 2010 Census.

The Connect America Fund Phase II will reduce the number of unserved areas in Tennessee.

In a report accompanying its broadband survey, ECD estimates the cost of expanding service to every home in Tennessee where no provider reported offering at least 10/1 or at least 25/3 as of June 2014 using either fiber-to-the-home or fixed wireless. For fiber-to-the-home, ECD says that

> the range of costs per household to build fiber is estimated between $2,500 to $3,840. These costs represent design, engineering, permitting, and fiber construction, including the labor, materials, equipment, shelters, and all components of the outside plant infrastructure.
>
> The total projected capital costs to build fiber to the housing units that do not meet the 10/1 definition is

[193] TACIR staff calculations using FCC Form 477 data reported as of December 31, 2015, and population data from 2010 census.

> between $819 Million to $1.25 Billion. The total capital costs to build fiber to the housing units that do not meet the 25/3 target are estimated to be between $1.17 to $1.716 Billion.[194]

Industry representatives, however, say that fiber-to-the-home build-outs in rural areas can cost at least $5,000 per location. It would cost approximately $1.6 billion to cover all homes where no provider reported offering 10/1 and $2.2 billion to all homes where no provider reported offering 25/3 using this higher estimate.[195]

For fixed wireless, ECD says that "using this approach, the total capital costs could be reduced by $800 [to] $1,400 per household." At $1,100 per location on the low end and $3,040 per location on the high end, the cost to build fixed wireless to every home where no provider reported offering 10/1 ranges from $361 million to $996 million, according to ECD. To provide fixed wireless to every home where no provider reported offering 25/3, the cost ranges from $492 million to $1.4 billion.[196] The low end of ECD's estimates for fixed wireless is similar to the predicted per location costs listed in documents regarding the Connect America Fund submitted to the FCC by Southern Tier Wireless, a fixed wireless provider serving the state of New York, which says that building fixed wireless networks capable of providing 25/3 costs approximately $1,200 per location in rural areas.[197]

Applying ECD's framework to the latest publicly available coverage data—December 2015—results in lower estimates because providers have continued to expand coverage. There are 193,881 housing units located in census blocks where no provider reported service of at least 10/1 as of December 2015 and 327,441 housing units in census blocks where no provider reported offering at least 25/3. Using the low end of ECD's per location estimate for fixed wireless and the high end of ECD's per location estimate for fiber-to-the-home, the cost to cover every home in the census blocks where no provider reported offering 10/1 in Tennessee as of December 2015 ranges from $213 million to $745 million. The cost to cover every home in the census blocks where no provider reported offering 25/3 ranges from $360 million to $1.3 billion. If the $5,000 per location estimate for fiber-to-the-home cited by Southern Tier Wireless is used instead, the cost at the upper end of the range would be $969 million to cover every home in the census blocks where no provider reported offering 10/1 and

[194] Tennessee Department of Economic and Community Development 2016.
[195] Southern Tier Wireless 2016.
[196] Tennessee Department of Economic and Community Development 2016.
[197] Southern Tier Wireless 2016.

$1.6 billion to cover every home in the census blocks where no provider reported offering 25/3. See table 3.

Table 3. Cost to Expand Broadband to Housing Units in Census Blocks where No Provider Reported either at Least 10/1 or 25/3 as of December 2015

Census Blocks as of December 2015	Number of Housing Units	Cost to Expand Coverage		
		Range of ECD Cost Estimates		Southern Tier Wireless Cost Estimate for Fiber-to-the-Home ($5,000 per location)
		Fixed Wireless Min. ($1,100 per location)	Fiber-to-the-Home Max. ($3,840 per location)	
No Provider Reported 10/1	193,881	$ 213,269,100	$ 744,503,040	$ 969,405,000
No Provider Reported 25/3	327,441	$ 360,185,100	$ 1,257,373,440	$ 1,637,205,000

Source: TACIR staff calculations based on December 2015 Form 477 data, population data from 2010 Census, Tennessee Department of Economic and Community Development 2016, and Southern Tier Wireless 2016.

But the estimates for serving homes where no provider reported 10/1 still don't account for broadband build-outs that will occur as part of the FCC's Connect America Fund phase II (CAF II). The CAF II program provides multi-year grants to large telephone companies—classified as price cap carriers—in exchange for commitments to expand coverage of at least 10/1 to a set number of homes and businesses in census blocks where

- no provider reported offering service of at least 3 megabits per second download and 0.768 megabits per second upload as of 2013;
- the individual cost of serving at least some of the locations in the census block with fiber-to-the-home is more than $52.50 per month but less than $198.60 per month; and
- no provider was either awarded funding or indicated that it wished to remain in consideration for funding through the Rural Broadband Experiments program.[198]

The FCC determined which blocks would be eligible for funding for each provider, the number of locations that providers must serve in exchange for accepting funding, and the amount of funding each provider would be offered. Providers had the opportunity to either accept or reject the FCC's funding offer on a state-by-state basis.[199] Those providers that accept

[198] Federal Communications Commission 2014b; Federal Communications Commission 2015f; and telephone interview with Heidi Lankau, attorney advisor, Federal Communications Commission, September 26, 2016. The FCC's Rural Broadband Experiments program awarded funding through a competitive bidding process based on cost effectiveness to several providers across the US but none in Tennessee; see, Federal Communications Commission 2014a; and Federal Communications Commission 2016k.

[199] Telephone interview with Heidi Lankau, attorney advisor, Federal Communications Commission, September 26, 2016.

funding but don't meet build-out requirements set by the FCC can have future funding withheld and may have to pay back past funding.[200]

Providers can choose what technology to use to build out their networks as part of CAF II. Although the FCC's funding formula is based on the cost of building fiber-to-the-home, providers can expand service using different technologies as long as they offer service of at least 10/1 with a data cap of at least 150 gigabytes—though 100 gigabytes is acceptable in some circumstances—at prices that are no greater than either a benchmark set annually by the FCC or the non-promotional prices the provider charges for comparable fixed wireline service in urban areas located in the same state where it receives CAF II support. Providers must file paperwork with the FCC annually in which they certify whether the prices they offer meet these requirements. The FCC audits a sample of the filings every year to verify the accuracy of the information provided.[201]

In Tennessee, all three providers offered funding through CAF II—AT&T, CenturyLink, and Frontier—accepted. Their funding totals approximately $30 million per year for up to seven years for a grand total of $210 million in exchange for expanding coverage to more than 93,000 homes and businesses in areas across the state.[202] There are still 113,830 housing units located in census blocks where no provider reported offering service of at least 10/1 as of December 2015 that are not eligible for CAF II. See map 2 and appendix I.

It is possible, however, for providers to meet their CAF II build-out requirements without expanding coverage to every location in every eligible block and potentially without expanding any coverage to some eligible blocks at all. The FCC did not include every location in CAF II eligible census blocks in providers' build-out requirements, and providers have flexibility to decide which locations to expand coverage to in these blocks. As noted above, the FCC determined the total number of locations that providers must expand coverage to and the funding they would receive through CAF II based on the number of locations in eligible census blocks that cost more than $52.50 but less than $198.60 per month to serve. But census block eligibility was determined in part based on service providers reported offering as of December 2013. Although providers have already expanded coverage to some of these blocks in the interim, the blocks are still eligible for CAF II funding, and providers can count locations in them toward their CAF II obligations despite the blocks already being served.

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[200] Federal Communications Commission 2014b.

[201] Telephone interviews with Heidi Lankau, attorney advisor, Federal Communications Commission, September 26, 2016, and December 9, 2016; Federal Communications Commission 2014b; Federal Communications Commission 2016c; and Federal Communications Commission 2016n.

[202] Federal Communications Commission 2014b; Federal Communications Commission 2015h; and Federal Communications Commission 2015g.

Additionally, some eligible census blocks contain both locations that fall within this cost range and other locations that do not. In these blocks, providers can count locations for which the calculated cost of service is either less than $52.50 per month or greater than $198.60 per month toward their build-out requirements if they expand coverage to them. Providers are also allowed to count locations for which the calculated cost of service is greater than $198.60 in otherwise ineligible census blocks that are adjacent to CAF II eligible blocks.[203] As a result, there could be an additional 46,041 housing units in CAF II eligible blocks that will remain unserved after the CAF II program even without accounting for coverage expansions to any locations for which the cost of service is above $198.60 in adjacent blocks.

Including both the 113,830 homes in remaining unserved census blocks ineligible for CAF II and the 46,041 housing units located in CAF II eligible census blocks that could remain unserved, there could be 159,871 unserved housing units remaining in blocks where no provider reported offering service of at least 10/1 as of December 2015. This range—113,830 to 159,871 housing units—represents a coverage gap that will need to be addressed. Using the low end of ECD's per location estimate for fixed wireless and the high end of ECD's per location estimate for fiber-to-the-home, the cost to cover the 113,830 homes in remaining unserved census blocks ineligible for CAF II ranges from $125 million to $437 million. If the $5,000 per location estimate for fiber-to-the-home cited by Southern Tier Wireless is used instead, the cost at the upper end of the range would be $569 million. The cost to cover 159,871 homes—which includes both those in remaining unserved census blocks ineligible for CAF II and the 46,041 homes in CAF II eligible blocks that providers won't have to expand coverage to—ranges from $176 million to $614 million using ECD's per location estimates and up to $799 million using Southern Tier Wireless' estimate for fiber-to-the-home. See table 4.

Table 4. Cost to Expand Broadband to Housing Units in Census Blocks where No Provider Reported at Least 10/1 as of December 2015, Accounting for CAF II

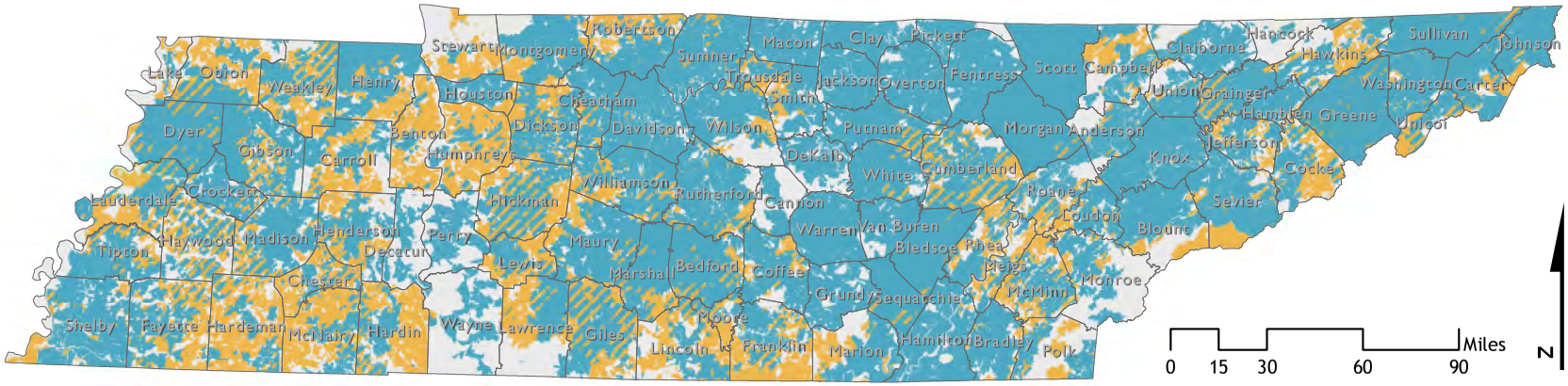
Remaining Unserved Census Blocks where No Provider Reported 10/1 as of December 2015	Number of Housing Units	Cost to Expand Coverage		
		Range of ECD Cost Estimates		Southern Tier Wireless Cost Estimate for Fiber-to-the-Home ($5,000 per location)
		Fixed Wireless Min. ($1,100 per location)	Fiber-to-the-Home Max. ($3,840 per location)	
After All Housing Units in CAF II Eligible Blocks are Served	113,830	$ 125,213,000	$ 437,107,200	$ 569,150,000
Including Housing Units in CAF II Eligible Blocks that Could Remain Unserved	159,871	$ 175,858,100	$ 613,904,640	$ 799,355,000

Source: TACIR staff calculations based on December 2015 Form 477 data, Connect America Cost Model (CAM v4.3) Phase II Blocks Released April 29, 2015, population data from 2010 Census, Tennessee Department of Economic and Community Development 2016, and Southern Tier Wireless 2016.

Some approaches to enable expansion of coverage to the remaining gap of housing units include providing grants, reducing providers' tax burdens, reducing local regulation, encouraging public-private partnerships, and coordinating the efforts of federal, state, and local governments both with each other and with businesses and non-profit organizations.

[203] Telephone interview with Heidi Lankau, attorney advisor, Federal Communications Commission, September 26, 2016; Federal Communications Commission 2014b; Federal Communications Commission 2015f; Federal Communications Commission 2015i; and Federal Communications Commission 2016c.

Map 2. Census Blocks Eligible for Connect America Fund Phase II Support in Tennessee



Connect America Fund:
Phase II Funding Eligible Areas

- Not Eligible for CAF-II; 10 Mbps Service Reported
- CAF-II Funding Eligible; 10 Mbps Service Reported
- Not Eligible for CAF-II; 10 Mbps Service Not Reported
- CAF-II Funding Eligible; 10 Mbps Service Not Reported

Source: Federal Communications Commission List of Census Blocks Funded by Final Connect America Cost Model (CAM v4.3) released on April 29, 2015
https://www.fcc.gov/general/price-cap-resources
Fixed broadband coverage (DSL, Cable, Fiber, and Fixed Wireless) reported on FCC Form 477, December 31, 2015.

Alternatives for reducing the cost of expanding coverage in remaining unserved and underserved areas include grants, tax incentives, and pole attachment fees.

The Tennessee Electric Cooperative Association's observation about the barriers to expanding electric service in the 20th century holds true for broadband today. If cost per customer is too great and expected revenue is too low, providers cannot justify investing in unserved and underserved areas. Reducing the cost to providers of building out their networks through grants and tax incentives targeted to specific areas can help them make a business case for expanding coverage. While reducing pole attachment fees could also decrease costs for providers, the state's authority to regulate fees charged by municipal utilities and electric cooperatives served by the Tennessee Valley Authority may be limited.

Federal and State Grant and Loan Programs

In addition to CAF II, several federal grant and loan programs exist that can reduce the cost of expanding broadband infrastructure. Other states have also adopted their own grant programs to encourage providers to build out networks. The most successful of these provide competitive grants for projects in unserved and underserved areas. While there is a broadband deployment fund established under Tennessee law, it has never been funded by the state.

Connect America Fund: Alternative Model, Broadband Loop Support, and Auction

There are three additional Connect America Fund grant programs in various stages of being finalized. The Connect America Fund alternative model will provide grants to smaller telephone companies classified as rate-of-return carriers. As in CAF II, providers were offered funding in exchange for commitments to expand coverage to homes and businesses in unserved census blocks. The FCC again determined which blocks would be eligible for funding for each provider, the number of locations that each must serve in exchange for accepting funding, and the amount of funding each would be offered.[204]

Census block eligibility, funding, and the minimum capacity requirements for the CAF alternative model differ slightly from CAF II. For the CAF alternative model, the FCC has determined that census blocks are eligible if

- no unsubsidized competitor reported offering service of at least 10/1 as of June 30, 2015;

[204] Federal Communications Commission 2016a; and Federal Communications Commission 2016g.

- the provider receiving support through the program did not offer service of at least 10/1 using either fiber-to-the-home or cable modem technologies; and
- the average cost of serving locations in the census block with fiber-to-the-home is more than $52.50 per month.

Monthly funding for locations in the CAF alternative model is the difference between $52.50 and the cost of serving the location as calculated by the FCC up to a cap that varies by provider but is no greater than $200 per location. Locations where calculated costs result in funding below a provider's cap are considered fully funded and are included in the total number of locations to which the provider must offer service of at least 10/1. Unlike in CAF II, providers receiving funding through the CAF alternative model are required to offer service of at least 25/3 to a percentage of their total number of fully-funded locations based on the housing unit density of their service areas in the state. Also, while the CAF II program does not include funding for locations where the calculated cost of service is above its maximum threshold, the CAF alternative model does include funding for them equal to providers' maximum monthly per location caps. Locations where calculated costs result in funding above a provider's cap are therefore only partially funded; however, providers can meet their build-out requirements for these locations by offering coverage of 4/1 and in some cases less depending on the housing unit density of their service areas in the state.[205]

Three providers in Tennessee accepted final funding offers under the CAF alternative model.[206] As a result, 13,764 additional housing units located in census blocks ineligible for CAF II could have coverage expanded to them through the program. This would leave between 100,066 and 146,107 unserved housing units in remaining blocks where no provider reported offering service of at least 10/1 as of December 2015. The lower end of this range includes only the housing units in remaining unserved blocks that were ineligible for both CAF II and the CAF alternative model, while the upper end of this range also includes the 46,041 housing units located in CAF II eligible blocks that could still remain unserved after providers meet their CAF II build-out requirements. Using the low end of ECD's per location estimate for fixed wireless and the high end of ECD's per location estimate for fiber-to-the-home, the cost to cover 100,066 homes in remaining unserved census blocks ranges from $110 million to $384 million. If the $5,000 per location estimate for fiber-to-the-home cited by Southern Tier Wireless is used instead, the cost at the upper end of the

[205] Telephone interview with Katie King, special counsel, Federal Communications Commission, December 19, 2016; Federal Communications Commission 2016a; Federal Communications Commission 2016f; and Federal Communications Commission 2016g.
[206] Federal Communications Commission 2016o; and Federal Communications Commission 2017.

range would be $500 million. The cost to cover 146,107 homes—which includes 46,041 homes in CAF II eligible blocks that providers won't have to expand coverage to—ranges from $161 million to $561 million using ECD's per location estimates and up to $731 million using Southern Tier Wireless' estimate for fiber-to-the-home. See tables 5 and 6.

Additionally, rate-of-return carriers that did not accept offers under the CAF alternative model will receive funding through the CAF broadband loop support (CAF BLS) program. The CAF BLS program modifies the existing support program for rate-of-return carriers to include funding for customers who subscribe only to broadband service in addition to funding already provided for those who subscribe to telephone service alone or both telephone and broadband service. Providers that both receive funding through the CAF BLS program and offered broadband of at least 10/1 to less than 80% of their service areas as of June 2015 will be required to expand 10/1 service over the next five years to a set number of locations calculated using one of two methods adopted by the FCC. Each provider determined which method it would use.[207] Based on the providers that didn't accept funding offers through the CAF alternative model, build-out requirements for providers in Tennessee receiving funding through CAF BLS will total 5,841 locations.[208] If providers meet these build-out requirements by expanding coverage to residential locations alone, there would still be between 94,225 and 140,266 housing units remaining in blocks ineligible for CAF II or the CAF alternative model where no provider reported offering service of at least 10/1 as of December 2015. Again, the upper end of this range includes the 46,041 housing units located in CAF II eligible blocks that could still remain unserved after providers meet their CAF II build-out requirements.

Using the low end of ECD's per location estimate for fixed wireless and the high end of its estimate for fiber-to-the-home, the cost to cover 94,225 housing units in remaining unserved census blocks—which assumes that all units in CAF II eligible blocks are served—ranges from $104 million to $362 million. If the $5,000 per location estimate for fiber-to-the-home cited by Southern Tier Wireless is used instead, the cost at the upper end of the range would be $471 million. The cost to cover 140,266 homes—which includes the 46,041 homes in CAF II eligible blocks that providers won't have to expand coverage to—ranges from $154 million to $539 million using ECD's per location estimates and up to $701 million using Southern Tier Wireless' estimate for fiber-to-the-home. See tables 5 and 6.

[207] Federal Communications Commission 2016g.
[208] Federal Communications Commission 2016b; and email from Habib Simab, senior manager of high cost operations, Universal Service Administrative Company, January 19, 2017.

The FCC is also planning to award Connect America Fund grants for additional census blocks through an auction process. According to Douglas Jarrett, a partner at the law firm Keller and Heckman who specializes in telecommunications law,

> competitive providers will have the opportunity to bid on those census blocks for which the price-cap carriers decline statewide, model-based offers; competitive providers and price-cap ILECs will be able to bid on those high-cost areas that the FCC expressly excluded from the price-cap offers ("other high-cost areas").
>
> These other high-cost areas include census blocks in which subsidized or unsubsidized providers currently offer broadband in excess of 4 Mbps/1 Mbps but less than 10 Mbps/1 Mbps as well as those in which [Rural Broadband Experiment] applicants applied for funding for broadband at 100 Mbps/25 Mbps and met the basic financial and technical requirements but were not selected. The number of these other high-cost areas is expected to be a small fraction of the areas subject to the statewide offers.[209]

The preliminary list of eligible census blocks in each state includes approximately 13,000 homes and businesses in Tennessee.[210] Among these, there are 8,049 housing units located in blocks ineligible for CAF II, the CAF alternative model, and CAF BLS where no provider reported service of at least 10/1 as of December 2015. The FCC has not set a date for finalizing the list of eligible locations or holding the auction.[211]

If providers receive funding for and expand broadband to all of the housing units in unserved census blocks in the FCC's preliminary auction list that are ineligible for CAF II, the CAF alternative model, and CAF BLS, there would be between 86,176 and 132,217 unserved housing units remaining in blocks where no provider reported offering service of at least 10/1 as of December 2015. As noted above, the upper end of this range includes the 46,041 housing units located in CAF II eligible blocks that could still remain unserved after providers meet their CAF II build-out requirements. Using the low end of ECD's per location estimate for fixed wireless and the high end of ECD's per location estimate for fiber-to-the-home, the cost to cover 86,176 housing units in remaining unserved census blocks ranges

[209] Jarrett 2015.
[210] Federal Communications Commission 2016j.
[211] Telephone interview with Heidi Lankau, attorney advisor, Federal Communications Commission, December 9, 2016.

Table 5. Cost to Expand Coverage to Housing Units in Unserved Census Blocks after CAF II, Alternative Model, Broadband Loop Support, and Auction Assuming All Units in CAF II Eligible Blocks Are Served

Number of Housing Units Remaining in Census Blocks Where No Provider Reported 10/1 as of December 2015	Housing Units	Cost to Expand Coverage		
		Range of ECD Cost Estimates		Southern Tier Wireless Cost Estimate for Fiber-to-the-Home ($5,000 per location)
		Fixed Wireless Min. ($1,100 per location)	Fiber-to-the-Home Max. ($3,840 per location)	
Before Accounting for CAF	193,881	$ 213,269,100	$ 744,503,040	$ 969,405,000
After CAF II (assumes all units in eligible blocks are served)	113,830	$ 125,213,000	$ 437,107,200	$ 569,150,000
After CAF Alternative Model	100,066	$ 110,072,600	$ 384,253,440	$ 500,330,000
After CAF BLS Build-Out Requirements	94,225	$ 103,647,500	$ 361,824,000	$ 471,125,000
After CAF Auction	86,176	$ 94,793,600	$ 330,915,840	$ 430,880,000

Source: TACIR staff calculations based on December 2015 Form 477 data; Connect America Cost Model (CAM v4.3) Phase II Blocks Released April 29, 2015; Federal Communications Commission 2016a; Federal Communications Commission 2016b; Federal Communications Commission 2016j; Federal Communications Commission 2016o; Federal Communications Commission 2017; email from Habib Simab, senior manager of high cost operations, Universal Service Administrative Company, January 19, 2017; population data from 2010 Census; Tennessee Department of Economic and Community Development 2016; and Southern Tier Wireless 2016.

Table 6. Cost to Expand Coverage to Housing Units in Unserved Census Blocks after CAF II, Alternative Model, Broadband Loop Support, and Auction Assuming 46,041 Units in CAF II Eligible Blocks Remain Unserved

Number of Housing Units Remaining in Census Blocks Where No Provider Reported 10/1 as of December 2015	Housing Units	Cost to Expand Coverage		
		Range of ECD Cost Estimates		Southern Tier Wireless Cost Estimate for Fiber-to-the-Home ($5,000 per location)
		Fixed Wireless Min. ($1,100 per location)	Fiber-to-the-Home Max. ($3,840 per location)	
Before Accounting for CAF	193,881	$ 213,269,100	$ 744,503,040	$ 969,405,000
After CAF II (assumes 46,041 units in eligible blocks remain unserved)	159,871	$ 175,858,100	$ 613,904,640	$ 799,355,000
After CAF Alternative Model	146,107	$ 160,717,700	$ 561,050,880	$ 730,535,000
After CAF BLS Build-Out Requirements	140,266	$ 154,292,600	$ 538,621,440	$ 701,330,000
After CAF Auction	132,217	$ 145,438,700	$ 507,713,280	$ 661,085,000

Source: TACIR staff calculations based on December 2015 Form 477 data; Connect America Cost Model (CAM v4.3) Phase II Blocks Released April 29, 2015; Federal Communications Commission 2016a; Federal Communications Commission 2016b; Federal Communications Commission 2016j; Federal Communications Commission 2016o; Federal Communications Commission 2017; email from Habib Simab, senior manager of high cost operations, Universal Service Administrative Company, January 19, 2017; population data from 2010 Census; Tennessee Department of Economic and Community Development 2016; and Southern Tier Wireless 2016.

from $95 million to $331 million. If the $5,000 per location estimate for fiber-to-the-home cited by Southern Tier Wireless is used instead, the cost at the upper end of the range would be $431 million. The cost to cover 132,217 housing units—which includes the 46,041 homes in CAF II eligible blocks that providers won't have to expand coverage to—ranges from $145 million to $508 million using ECD's per location estimates and up to $661 million using Southern Tier Wireless' estimate for fiber-to-the-home. See tables 5 and 6.

Other Federal Grant and Loan Programs

There are several other federal grant and loan programs available to providers and communities for expanding broadband coverage. As described in a guidebook on broadband funding opportunities published by the office of Senator Kirsten Gillibrand of New York, some of these grant and loan programs include those provided by the US Department of Agriculture, the Appalachian Regional Commission, and the US Department of Health and Human Services:

> United States Department of Agriculture (USDA) Rural Development
>
> 1) Rural Broadband Access Loan and Loan Guarantee Program
>
> Provides loans and loan guarantees to eligible applicants, including telephone companies, telephone cooperatives, municipalities, nonprofit organizations, and tribes, to deploy infrastructures that provide broadband service in rural communities that meet the program's eligibility requirements.
>
> Additional Information:
>
> Broadband Service means any technology having the capacity to transmit at a minimum transmission speed of 200 kbps both from and to a residential subscriber. The rate of data transmission is subject to annual review and will be published in the Notice of Funds Availability at the beginning of each fiscal year.
>
> Loans maturities are equal to the composite economic life of the facilities financed. The interest rate for the Cost-of-Money program is equal to the cost of borrowing to the Department of Treasury for a comparable maturity.

The 4-Percent program interest rate is 4 percent and the maximum loan amount for the 4-Percent program is $7.5 million. The interest rate for the Guarantee program is set by the lender.

Eligibility:

Eligible rural communities are any area of the United States (which includes its territories and insular possessions) that is not contained in an incorporated city or town with a population in excess of 20,000 inhabitants, based on the most recent available information of the Bureau of the Census.

The following are eligible: cooperative, nonprofit, limited dividend or mutual associations, limited liability companies, commercial organizations, Indian tribes, tribal organizations, state government, local government, including those located in the U.S. territories and countries included in the Compact of Free Association Act of 1985, providing or proposing to provide broadband services in eligible rural communities.

2) Community Connect Broadband Grants Program

Provides community access to broadband services in unserved areas through a one-time grant to such organizations as tribes, cooperatives, private companies, and universities, and uses the infrastructure built by the grant to create opportunities for continued improvement.

Additional Information:

The funding will support construction, acquisition, or lease of facilities, including spectrum, to deploy broadband transmission services to all critical community facilities and to offer such service to all residential and business customers located within the proposed service area.

The funding can be put towards the improvement, expansion, construction, acquisition, or leasing of a community center that furnishes free access to broadband Internet service, provided that the community center is open and accessible to area residents before, during, and after normal working hours and on Saturday or Sunday.

All equipment purchased with grant and/or matching funds must be new or non-depreciated.

Eligibility:

Applicants must be organized as an incorporated organization, an Indian tribe or tribal organization, a state or local unit of government, or other legal entity, including cooperatives or private corporations or limited liability companies organized on a for profit or not-for profit basis.

The project must deploy Basic Broadband Transmission Service, free of all charges for at least 2 years, to all Critical Community Facilities located within the proposed Service Area. Additionally, it should offer Basic Broadband Transmission Service to residential and business customers within the proposed Service Area.

3) Telecommunications Infrastructure Loan Program

The Telecommunications Infrastructure Loan Program makes long-term direct and guaranteed loans to qualified organizations for the purpose of financing the improvement, expansion, construction, acquisition, and operation of telephone lines, facilities, or systems to furnish and improve Telecommunications service in rural areas.

Additional Information:

Long-term direct and guaranteed loans to qualified organizations for the purpose of financing the improvement, expansion, construction, acquisition, and operation of telephone lines, facilities, or systems to furnish and improve Telecommunications service in rural areas.

"Rural area" is defined as any area of the United States, its territories and insular possessions (including any areas within the Federated States of Micronesia, the Republic of Palau) not included within the boundaries of any incorporated or unincorporated city, village, or borough having a population exceeding 5,000 inhabitants.

Applications are accepted year round and are not competitive. The types of loans offered include; cost-

of-money loans, guaranteed loan (including federal financing bank loans) and hardship loans.

Eligibility:

Eligible applicants consist of telephone companies or cooperatives, nonprofit associations, limited dividend associations, mutual associations or public bodies including those located in the U.S. Territories and countries included in the Compact of Free Association Act of 1985, providing or proposing to provide telecommunications service to meet the needs of rural areas.

A beneficiary must be a resident of rural areas and others who may also receive telephone service as a result of service provided to a rural area.

4) Distance Learning and Telemedicine [DLT] Loans and Grants Program

Provides loans and grants to rural community facilities (e.g., schools, libraries, hospitals, and tribal organizations) for advanced telecommunications systems that can provide health care and educational benefits to rural areas.

Additional Information:

The DLT Program provides three kinds of financial assistance; a full grant, grant-loan combination, and a full loan.

Eligibility:

To be eligible for a grant, your organization must:

- Currently deliver or propose to deliver distance learning or telemedicine services for the term of the grant. To receive a grant, the purposes must meet the grant definition of distance learning and telemedicine. The DLT program is focused on sustainability. Planning studies, research projects, and short-term demonstration projects of less than two years will not be considered.

- Be legally organized as an incorporated organization or partnership; an Indian tribe or tribal organization; a state or local unit of government; a consortium; or

other legal entity, including a private corporation organized on a for profit or not-for profit basis with the legal capacity to contract with the United States Government.

- Operate a rural community facility or deliver distance learning or telemedicine services to entities that operate a rural community facility or to residents of rural areas at rates calculated to ensure that the benefit of the financial assistance passes through to such entities or to residents of rural areas.

Appalachian Regional Commission (ARC)

Appalachian Regional Commission Project Grant Program

This program awards grants to projects that create jobs and improve infrastructure, enabling the people of Appalachia to compete in a global economy. These grants include funds that may be used to improve broadband access, such as distance learning, telehealth/telemedicine, e-government, and e-business applications and workforce development.

Additional Information:

Most ARC project grants originate at the state level. Potential applicants should contact their state's ARC program manager, whose contact info is below, to request a pre-application package.

ARC project grants can be used for business development and entrepreneurship, education and training, health care access, physical infrastructure, including broadband, and leadership development and civic capacity.

United States Department of Health and Human Services: Health Resources and Services Administration

1) Telehealth Network Grants

Funds proposals that develop sustainable telehealth programs and networks in rural and frontier areas.

Additional Information:

Telehealth Network grants are competitively awarded to proposals that best demonstrate the use

of telehealth networks to improve healthcare services for the medically underserved in rural and frontier communities.

Eligibility:

HRSA rural health programs fund rural hospitals, health centers, local clinics, and other qualified health organizations.

2) Telehealth Resource Center Grant Program

Provides grants that support the establishment and development of telehealth resource centers to assist healthcare providers in the development of telehealth services, including decisions regarding the purchase of advanced telecommunications services.

Additional Information:

Telehealth Network grants are competitively awarded to proposals that provide the best support for the establishment of Telehealth Resource Centers. These centers are to assist healthcare organizations, healthcare networks, and healthcare providers in the implementation of cost-effective telehealth programs in medically underserved rural populations.

Eligibility:

HRSA rural health programs fund rural hospitals, health centers, local clinics, and other qualified health organizations.[212]

The US Department of Education, US Department of Housing and Urban Development, Institute of Museum and Library Services, and US Department of Commerce also have programs listed in the guidebook published by Senator Gillibrand's office. See appendix J.

State-Based Grant Programs

Several states have their own grant programs for expanding broadband coverage. The most successful of these, including Maine and Minnesota, use a competitive application process to choose projects to ensure that state funds maximize coverage in unserved and underserved areas. Maine's infrastructure grant program has resulted in almost 39,000 homes and businesses getting access to broadband since 2007. The program provides

[212] Gillibrand 2015.

approximately $1 million per year in competitive grants to providers to expand coverage in unserved and underserved areas. The state defines unserved areas as those without access to at least 1.5 megabits per second download, and it defines underserved areas as those with at least 1.5 megabits per second download but less than 10 megabits per second download. Grant applications are scored in part on the improvement in the maximum capacity that will be offered to the area but must result in minimum service of 10 megabits per second download and 10 megabits per second upload. The technology used to provide service is not scored. Grant recipients are expected to provide matching funds; overall, the program tries to achieve a 50-50 ratio between grants and provider matches, but the ratio for individual projects may vary. The program is funded through a 0.25% tax on communications services.[213]

Minnesota's Border-to-Border Broadband Development Grant Program funded projects for approximately 6,000 homes and businesses in 2015.[214] Like Maine, Minnesota uses a competitive application process and grants are only available for unserved and underserved areas. Minnesota, however, currently defines unserved areas as those without access to 25/3 from a wireline provider, and it defines underserved areas as those with access of at least 25/3 but less than 100 megabits per second download and 20 megabits per second upload from a wireline provider. Minnesota's program requires recipients to provide at least 50% of project costs and caps individual awards at $5 million. Local governments and for-profit and non-profit providers are all eligible to apply. While recipients have some flexibility when determining what technologies they will use for their networks, they must provide wireline service. Whereas Maine funds its program through a tax on telephone service, Minnesota relies on annual appropriations from the state's legislature, which appropriated $35 million for 2016 with $500,000 reserved for low-income areas and $5 million reserved for underserved areas.[215]

Similar programs exist in Wisconsin, Vermont, and Colorado. Wisconsin's Broadband Expansion Grant program has up to $1.5 million in grants available per year and is managed by the state's public service commission. Priority is given to projects in unserved or underserved census blocks. Broadband is defined as wireline or fixed wireless service of at least 25/3, not including satellite service, and underserved areas are those that

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[213] Memorandum announcing 10th round of grants from Phil Lindley, executive director, ConnectME Authority, February 26, 2016, http://www.maine.gov/connectme/grants/infrastructure/docs/ConnectME_BroadbandGrantTenthCvrLtr.doc; ConnectME Authority 2016; and ConnectME Authority 2015.

[214] Minnesota Department of Employment and Economic Development 2015.

[215] Minnesota Department of Employment and Economic Development "Broadband Grant Program: Overview"; and Minnesota Department of Employment and Economic Development 2016.

don't have access to at least two providers offering service that meets the state's definition. In fiscal year 2014 and fiscal year 2015, the program resulted in completed projects that have expanded or improved service to approximately 3,300 homes.[216]

Vermont's Connectivity Initiative is also managed by the state's public service commission. The commission determines which census blocks in the state are eligible for funding. The program uses a competitive application process to award grants, and recipients are obligated to provide a minimum of 10/1 service. The program awarded almost $886,000 in grants in 2015 to serve 175 locations and is funded by a 2% tax on all retail telecommunications services in the state and penalties collected from providers of wholesale telecommunications services that don't meet their required performance standards.[217]

Colorado's Broadband Deployment Fund had up to $2.4 million available in its first grant cycle. Grants can cover up to 75% of infrastructure costs for a project but can only be used in contiguous areas where the majority of households lack access to at least one satellite provider and at least one non-satellite provider that both offer service of at least 25/3. Eligible areas must also be unincorporated or located in cities with fewer than 5,000 residents but not in an area required to be served under an existing franchise agreement. Funds cannot be used to duplicate those received from other federal or state programs. Recipients are limited to telephone cooperatives and electric cooperatives that existed as of May 10, 2014 as well as for-profit companies. Recipients must provide service for at least five years at a capacity of at least 25/3 and must begin service within two years.[218]

California and New York also have broadband grant programs, but they rely on much greater levels of funding. California's Advanced Services Fund was established in 2007 as a $100 million grant and loan program, and it received an additional $125 million in 2010. The program's infrastructure grant and revolving loan account had awarded almost $100 million in grants and loans in support of 51 projects benefiting approximately 300,000 households as of 2015.[219] New York's broadband grant program, which awarded its first grants in 2016, will provide $500 million in funding through 2018 to expand coverage.[220]

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[216] Wisconsin Public Service Commission 2016; Wisconsin Revised Statutes 196.504; Wisconsin Public Service Commission "Summary of FY 2014 Broadband Grants"; and Wisconsin Public Service Commission "Summary of FY 2015 Broadband Grants."
[217] Vermont Department of Public Service 2015.
[218] Colorado Department of Regulatory Agencies 2016a; and Colorado Department of Regulatory Agencies 2016b.
[219] California Public Utilities Commission 2016; and California Public Utilities Commission 2015.
[220] Shueh 2016; and New York Governor's Office 2016.

While these grant programs all fund projects that provide service directly to end users, some states also have programs that fund construction of middle-mile infrastructure to connect communities to the wider internet. Colorado, for example, has a $20 million grant program for middle-mile infrastructure,[221] and in Massachusetts, a 1,200 mile fiber-optic network connecting 123 communities in the western and north central parts of the state was completed in 2014 using more than $44 million in state grants in addition to more than $45 million in federal grants.[222] Massachusetts also completed a middle-mile network on Cape Cod in 2013 using $5 million in state funds to leverage $32 million in federal funding.[223] Similarly, Kentucky is partnering with several private companies, including Macquarie Capital, a venture capital firm, to build a middle-mile network to ensure that all communities in the state have fiber-optic connections to the wider internet.[224]

There are communities in Tennessee that don't have their own points of presence where they can connect directly to middle-mile networks and the internet backbone.[225] It can cost more to provide service in these communities, according to at least one provider interviewed.[226] But others cautioned that subsidizing the construction of middle-mile networks alone won't necessarily increase broadband access in unserved areas unless grants are conditioned on providers also making service directly available to end users.[227]

Tennessee Broadband Deployment Fund

A broadband deployment fund is already established under Tennessee law. Tennessee Code Annotated, Section 7-59-315, tasks the Tennessee Regulatory Authority (TRA) with developing guidelines in consultation with Connected Tennessee for administering the fund. Any grants from the fund are to be used to expand broadband coverage in unserved areas. Grants can be made to local governments as well as providers. The fund relies on appropriations from the General Assembly, but no money has been appropriated to it.

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[221] Colorado Department of Local Affairs "Broadband Program Grants and Eligibility."
[222] Massachusetts Broadband Institute "MassBroadband 123 Network."
[223] Massachusetts Broadband Institute "OpenCape"; and Massachusetts Broadband Institute "History."
[224] Kentucky Wired 2016; and Kentucky Wired "Quick Facts."
[225] Clarksville-Montgomery County Planning Team and Connected Tennessee 2015.
[226] Interview with Ben Lovins, senior vice president, telecommunications division, Jackson Energy Authority, August 11, 2016.
[227] Telephone interview with Ramona Carlow, vice president, public policy, AT&T, Mike Lieberman, assistant vice president, external affairs and regulatory, AT&T, Beth Fujimoto, assistant vice president, regulatory, AT&T, and Joelle Phillips, president, AT&T Tennessee, October 14, 2016; and email from Jeff Van Dyke, vice president, government affairs, AT&T Tennessee, December 22, 2016.

Taxes

At the Commission's May 2016 meeting, representatives of for-profit providers and telephone cooperatives said that the state could facilitate the expansion of coverage by exempting providers from sales taxes on equipment purchases. Moreover, representatives of for-profit telephone companies and telephone cooperatives said that assessing their telecommunications property at the commercial rates for property tax purposes, like cable television companies, rather than at the higher utility rates could help them invest more in their networks.[228] But simply eliminating or reducing these taxes across the board does not necessarily encourage providers to provide service in previously unserved or underserved areas. Several other states, however, have adopted tax credits that are tailored to encourage broadband development in areas that currently lack it.

Equalizing Assessment Rates for Property Tax Purposes

Tennessee is one of only eight states—including Alabama, Kansas, Louisiana, Maryland, Mississippi, Montana, and Oklahoma—that assess the telecommunications property of legacy telephone companies at higher rates for property tax purposes than the telecommunications property of legacy cable television companies.[229] In Tennessee, telephone companies' telecommunications property is assessed at the 55% utility rate whether personal or real, while cable television companies' telecommunications property is assessed at the commercial rates of 30% for personal property and 40% for real property. At the Commission's May 2016 meeting, representatives for telephone companies said that assessing their property at the lower commercial rates would put them on equal footing with cable television companies.[230]

Assessing telephone companies' telecommunications property at the commercial rates rather than the utility rate for property tax purposes would reduce local revenue by more than $16 million per year, according to the Tennessee Comptroller of the Treasury.[231] Further, of the eight states that assess telephone companies at higher rates than cable companies, Tennessee is one of three—including Kansas and Louisiana—that partially offset the additional taxes these companies pay.[232] Tennessee's ad valorem tax reduction fund was established in 2000 and is funded by a tax on telephone companies' business customers. The Tennessee Comptroller of the Treasury determines what each telephone company would owe if it

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[228] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[229] National Conference of State Legislatures 2015.
[230] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[231] Email from Gary Harris, director, office of state assessed properties, Tennessee Comptroller of the Treasury, October 7, 2016.
[232] National Conference of State Legislatures 2015.

were assessed at the lower commercial rates rather than the utility rate and distributes the difference between the two from the fund to each company. If the fund does not have enough money to compensate each company fully, then payments are distributed based on each telephone company's contribution to it. The fund paid out more than $9 million in 2016.[233]

Sales Tax on Broadband Equipment Purchases

Twenty-two states and the District of Columbia don't tax the sale of broadband equipment. Five—Alaska, Delaware, Montana, New Hampshire, and Oregon—have no sales tax. The rest—Arizona, Connecticut, the District of Columbia, Hawaii, Indiana, Iowa, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Utah, and West Virginia—exempt the purchase of broadband equipment from sales taxes.[234] Tennessee already exempts the purchase of equipment for certain industries from sales taxes.[235] Exempting the purchase of broadband equipment as well would reduce state revenue by approximately $45.5 million per year and local revenue by approximately $16.3 million per year, according to the Tennessee Department of Revenue.[236]

Simply exempting the purchase of broadband equipment from sales taxes regardless of where it is deployed would not necessarily encourage providers to expand coverage in unserved areas. Of the states that don't tax broadband equipment purchases, Mississippi provides a 100% exemption in moderately developed and less developed counties, which it designates as tier two and tier three counties, and only a 50% exemption in developed counties, which it designates as tier one counties.[237]

Tax Credits

Mississippi and Georgia offer tax credits to providers for making broadband infrastructure investments in underdeveloped areas. Mississippi offers tax credits for purchases of broadband equipment that can be applied to up to 50% of providers' aggregated franchise and income taxes. Credits can be taken annually for up to 10 years beginning with the year the equipment is put in service. The annual credits are equal to a percentage of the cost of the equipment and vary based on where the equipment will be put in service:

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[233] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016; and Tennessee Code Annotated, Section 67-6-221 and 222.
[234] Email from Jeff Van Dyke, vice president, government affairs, AT&T Tennessee, September 28, 2015; and Moreno 2016.
[235] Tennessee Code Annotated, Section 67-6-301 et seq.
[236] Email from Barbara Sampson, assistant commissioner, Tennessee Department of Revenue, October 25, 2016.
[237] Mississippi Department of Revenue 2016.

- 15% in less developed counties (tier 3)
- 10% in moderately developed counties (tier 2)
- 5% in developed counties (tier 1)

Unused credits in any year can be carried forward for up to ten years, but the total value of credits taken cannot exceed the original cost of equipment.[238]

Like Mississippi, Georgia offers tax credits for infrastructure investment, including telecommunications infrastructure, that vary based on where equipment is put in service. Georgia's credit can be used to offset up to 50% of providers' state corporate income tax liabilities, and if credits exceed that threshold, they can be carried forward for up to 10 years as long as the equipment remains in service. Credits are equal to

- 5% of capital investment of at least $50,000 in the state's 71 least developed counties based on unemployment, per capita income, and poverty levels;
- 3% of investment of at least $50,000 in the counties ranked from 72 through 106 least developed; and
- 1% in all remaining counties.[239]

Idaho and Pennsylvania also offer tax credits for broadband infrastructure investment, but they are not tied to expanding coverage in underdeveloped areas. Idaho offers two tax credits. One of Idaho's credits is equal to 3% of the value of broadband infrastructure investments and can be applied to providers' income and franchise taxes. The credit is capped at the lesser of taxes owed or $750,000 annually, though any credits exceeding the cap can be carried forward for up to 14 years. Idaho's other credit is also equal to 3% of the value of broadband infrastructure investments and can be applied to up to 50% of providers' income tax liabilities. Credits exceeding the cap can also be carried forward for up to 14 years, but credits can also be recaptured if it's determined by the state utility commission that the investment no longer qualifies for the credit.[240]

Pennsylvania offers a credit for mobile broadband equal to 5% of the purchase price of equipment placed into service in the previous tax year. The credit can be applied to up to 50% of providers' income taxes, but the total amount of credits for all providers in the state is capped at $5 million per year. Unused credits can be carried forward for up to five years.[241]

Tax credit programs for other industries, such as the low-income housing tax credit (LIHTC), award credits through competitive application

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[238] Ibid.
[239] Official Code of Georgia Annotated, Section 48-7-40 et seq.
[240] Idaho Revised Statutes, Section 63-3029I; and Idaho Revised Statutes, Section 63-3029B.
[241] Pennsylvania Department of Revenue "Mobile Telecommunications Broadband Investment Tax Credit Application."

processes. According to the Commission's 2015 report on assessing low-income housing tax credit properties,

> the LIHTC program encourages private investment in low-income housing by distributing federal tax credits through state housing agencies to developers. Each year, the Internal Revenue Service (IRS) allocates credits to states in proportion to their population. These allocations are only the first year of a ten-year flow of tax credits. The $14,940,749 in credits that was allocated to Tennessee in 2014 actually represents a total flow of almost $150 million in credits to be taken over ten years.
> . . .
>
> . . . Because each state's supply of credits is capped, the IRS requires state housing agencies to allocate them through a competitive process to maximize the number of high-quality low-income housing units constructed or rehabilitated.[242]

Developers must agree to restrictions on both the rents and incomes of tenants. In most projects, all of the units are rent-and-income-restricted "both to increase the project's likelihood of being allocated credits and because the amount of credits allocated is based on the number of rent-and-income-restricted housing units in a project."[243] The program is widely considered a success and remains politically popular.[244]

Pole Attachment Fees

Fees paid by broadband providers to attach cables and other equipment to utility poles owned by electric utilities and telephone companies also affect the cost of service. In February 2016, the Tennessee Valley Authority (TVA) adopted a formula for calculating pole attachment fees that may nearly double the current median fee charged by the utilities and cooperatives that TVA serves.[245] TVA's formula will apply to most of the utility poles

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[242] TACIR 2015.
[243] Ibid.
[244] Ibid.
[245] Memorandum from John M. Thomas, III, executive vice president and chief financial officer, Tennessee Valley Authority, to Tennessee Valley Authority Board of Directors, January 22, 2016, https://www.tva.com/file_source/TVA/Site%20Content/About%20TVA/Guidelines%20and%20Reports/tva_determination_on_regulation_of_pole_attachments.pdf; and Minutes of the Meeting of the Board of Directors, Tennessee Valley Authority, February 11, 2016, approved May 5, 2016, https://www.tva.com/file_source/TVA/Site%20Content/About%20TVA/Our%20Leadership/Board%20of%20Directors/Meetings/2016/2-11-2016%20Board%20Meeting%20Minutes%20-%20Chattanooga,%20TN%20(Ripped%20PDF).pdf.

in Tennessee,[246] though not all of the attachments on them,[247] and results in larger fees than formulas adopted by the FCC,[248] which apply to providers attaching equipment to poles owned by for-profit electric utilities and for-profit telephone companies in states that have not opted out of the FCC's guidelines.[249]

At its May 2016 meeting, the Commission heard from representatives of broadband providers, including AT&T, the Tennessee Telecommunications Association, and the Tennessee Cable Telecommunications Association. These industry representatives said that pole attachment fees can be barriers to expansion and that they could become increasingly important as providers deploy the next generation of wireless broadband networks, which may rely on attaching transceivers to utility poles rather than towers.[250] In a report accompanying its 2016 broadband survey, ECD says that "standardizing and minimizing the pole attachment rates can eliminate uncertainty and reduce costs, which is particularly important in higher cost, rural areas."[251]

But according to the Tennessee Electric Cooperative Association, the effect of pole attachment fees has been

> discussed frequently by the Utilities Telecom Council (UTC), which is a trade association representing the interests of electric, gas, water, pipeline, and other critical infrastructure companies that own, manage or provide telecommunications services in support of their core business. In recent formal comments to the FCC, UTC estimated that pole attachments constitute as little as 1% to 2% of the overall cost of deploying broadband.[252]

Moreover, representatives for providers at the Commission's May 2016 meeting said that although it would help in some communities, reducing pole attachment rates alone would not guarantee that providers could serve every area in the state because too many other factors affect the cost

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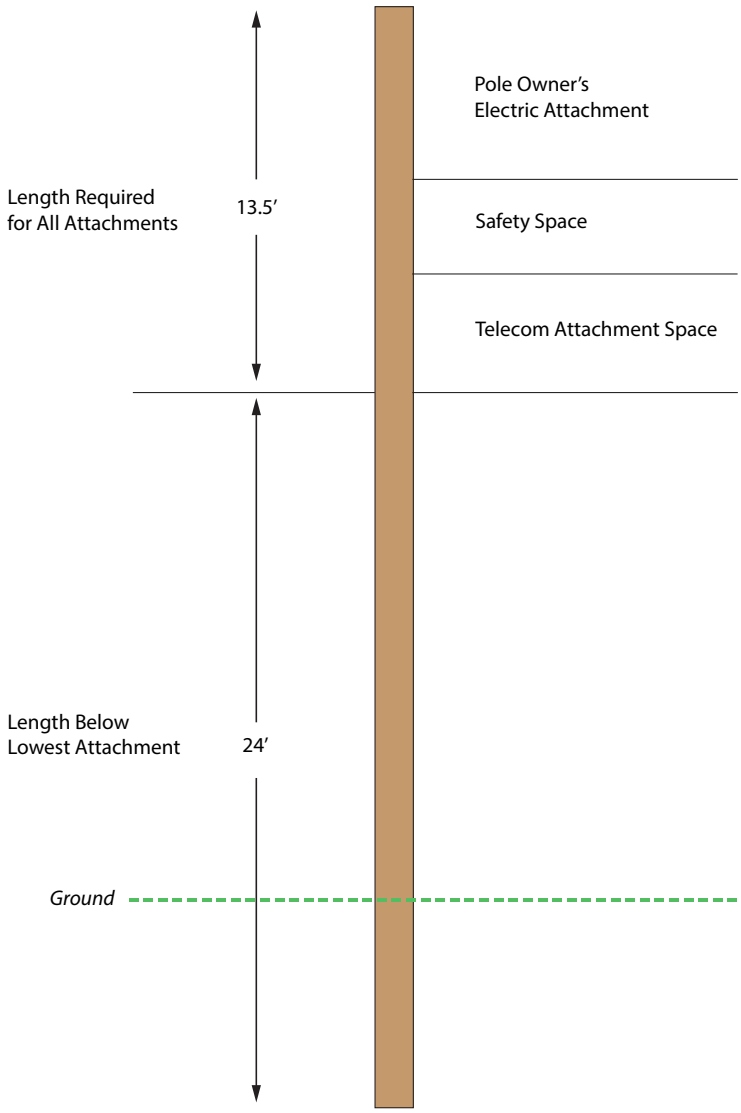
[246] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[247] Telephone interview with Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Yingying Ayliffe, managing attorney, office of general counsel, Tennessee Valley Authority, January 9, 2017.
[248] TACIR staff calculations based on example developed by TVA; see, appendixes K and M.
[249] 47 US Code 224; and 47 Code of Federal Regulations 1.1401 et seq.
[250] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[251] Tennessee Department of Economic and Community Development 2016.
[252] Memorandum from Tennessee Electric Cooperative Association to TACIR, October 21, 2015, https://www.tn.gov/assets/entities/tacir/attachments/2015OctoberTab3BB_TECA.pdf.

of expanding broadband networks. They also acknowledged that reimbursement for pole maintenance is a legitimate concern of pole owners.[253]

When comparing pole attachment fees derived from TVA's and the FCC's formulas, keep in mind that their statutory purposes differ: TVA's mandate is to provide its service area with electricity at rates as low as feasible;[254] the FCC's goal is to promote deployment and adoption of broadband internet access services.[255] These differences are clearly reflected in their formulas. Compared with the FCC's formulas, TVA's formula shifts more of a pole's cost to attachers, primarily by allocating more of the pole's length to them. To understand the formulas, it helps to divide the poles into segments from bottom to top (see figure 2):

- the length in the ground
- the length from ground-level up to the lowest attachment (telecommunications attachments are always below electric attachments)
- the length required for telecommunications attachments
- the "safety space" that separates electric attachments from telecommunications attachments to protect workers
- the length required for electric attachments

Figure 2. Utility Pole Diagram



Note: Both the FCC and TVA formulas assume a 37.5 foot pole with 13.5 feet required for attachments and 24 feet below the lowest attachment, including the length in the ground.
Source: 47 Code of Federal Regulations 1.1418 and TVA (see appendix K).

[253] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[254] 16 US Code 831; and email from Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, December 1, 2016.
[255] Federal Communications Commission 2015c.

Overview of Pole Attachment Fee Regulation

Regulatory oversight for pole attachment fees depends on several factors, including whether a pole is owned by a for-profit or non-profit entity and whether a state has adopted its own regulations. Fees charged for attaching to poles owned by for-profit companies are subject to Federal Communications Commission (FCC) guidelines unless a state has adopted its own. The FCC guidelines establish formulas for calculating the maximum per-pole fees that pole owners may charge as well as the amount of time that pole owners may take when responding to attachment requests.[256] Twenty states and the District of Columbia have adopted their own guidelines; Tennessee has not.[257]

The FCC guidelines, however, do not apply to poles owned by non-profit entities regardless of whether a state has adopted its own guidelines.[258] As a result, attachment fees for most utility poles in Tennessee are not subject to FCC guidelines because the majority of poles in the state—approximately 80%, according to the Tennessee Cable Telecommunications Association—are owned by municipal electric utilities or electric cooperatives.[259] The abundance of these municipally and cooperatively owned utilities in Tennessee is a product of 1930s-era legislation that created TVA and authorized it to sell electricity to local utilities for resale with preference to be given to "[s]tates, counties, municipalities, and cooperative organizations of citizens or farmers, not organized or doing business for profit."[260] According to the Commission's 2007 pole attachment report prepared by Dr. Reuben Kyle and Dr. Chris Klein and submitted by the Commission without comment,

> among the 50 states and the District of Columbia, Tennessee is exceptional in the extent to which electric power, and *hence the largest share of utility pole ownership*, is provided by municipal electric distributors and cooperatives. Only Nebraska compares with Tennessee in this regard.[261] (emphasis added)

TVA's Formula for Calculating Pole Attachment Fees

TVA's board of directors adopted a formula for calculating the pole attachment fees charged by the utilities and cooperatives it serves at the

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[256] 47 US Code 224; 47 Code of Federal Regulations 1.1401 et seq.; and Federal Communications Commission 2015c.
[257] Federal Communications Commission 2010b.
[258] 47 US Code 224; and 47 Code of Federal Regulations 1.1401 et seq.
[259] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[260] 16 US Code 831i.
[261] TACIR 2007.

Authority's board meeting on February 11, 2016.[262] The formula will apply to new or renewal pole attachment contracts that don't meet TVA's definition of a joint use or reciprocal agreement, which TVA plans to finalize in spring 2017.[263] Although TVA has neither previously adopted nor enforced a specific pole-attachment-fee formula, its contracts with the utilities and cooperatives it serves include provisions to ensure they operate for the benefit of electric ratepayers and keep electric rates as low as feasible. The adopted formula divides an estimate of the annual costs of pole ownership between all attaching entities, including the utility or cooperative and all telecommunications attachers. As described by TVA,

> under this rate methodology, the pole attachment rate is calculated by first establishing the total annual cost of pole ownership, which includes administration, depreciation, maintenance, taxes, and return on investment (ROI). The total cost is then allocated among pole users based on the actual number of pole users, an equal allocation of support space among the pole users, an equal allocation of safety space among pole users that are attaching for communications purposes, and an allocation of usable space to each pole user.[264] See appendix K.

For practical purposes, this means that TVA's formula determines attachment fees by

1. allocating a percentage of a pole's overall length to each attaching entity by
    a. determining the amount of space each entity's attachments actually require;
    b. dividing all space on the pole below the minimum attachment height, including all of the pole that is buried underground, equally among all attachers;
    c. dividing the space required to separate electric attachments from telecommunications attachments

[262] Minutes of the Meeting of the Board of Directors, Tennessee Valley Authority, February 11, 2016, approved May 5, 2016, https://www.tva.com/file_source/TVA/Site%20Content/About%20TVA/Our%20Leadership/Board%20of%20Directors/Meetings/2016/2-11-2016%20Board%20Meeting%20Minutes%20-%20Chattanooga,%20TN%20(Ripped%20PDF).pdf.

[263] Telephone interview with Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Yingying Ayliffe, managing attorney, office of general counsel, Tennessee Valley Authority, January 9, 2017.

[264] Memorandum from John M. Thomas, III, executive vice president and chief financial officer, Tennessee Valley Authority, to Tennessee Valley Authority Board of Directors, January 22, 2016, https://www.tva.com/file_source/TVA/Site%20Content/About%20TVA/Guidelines%20and%20Reports/tva_determination_on_regulation_of_pole_attachments.pdf.

for worker safety equally among telecommunications attachers;

d. dividing the sum of the values from steps (a), (b), and (c) by overall pole length; and

2. multiplying the fraction calculated in step (1) by an estimate of the annual cost per pole, which is based on return on investment, net pole investment and net investment for the overall utility plant—both calculated using the utility's annual financial filings with the Federal Energy Regulatory Commission (FERC) and TVA—and maintenance expenses for poles, administrative expenses and taxes for the overall utility plant, and depreciation, each reported in the same financial filings. See figure 3 and appendixes K and L.

Figure 3. TVA Pole Attachment Fee Formula

$$Fee = \left(\frac{Space\ Occupied\ by\ Attacher + \left(\frac{Safety\ Space}{\#\ Telecom\ Attachers}\right) + \left(\frac{Space\ Below\ Lowest\ Attachment}{Total\ \#\ Attachers}\right)}{Total\ Pole\ Length} \right) \times (Est.\ Annual\ Pole\ Cost)$$

Whether and where municipal utilities and electric cooperatives attach their own telecommunications equipment on their poles can affect the fees calculated for other attachers under TVA's formula. Those utilities and cooperatives that attach telecommunications equipment in the space reserved for telecommunications attachments are, like other telecommunications attachers, allocated an equal share of the space required for separating electric attachments from telecommunications attachments for worker safety—so-called safety space—in addition to the actual space used by their telecommunications attachment, which also reduces the space below the lowest attachment that is allocated equally among all attachers. While the utility or cooperative still only counts as a single attacher rather than multiple attachers for purposes of allocating the space below the lowest attachment, this reduces fees calculated for other attachers under the formula compared with fees calculated when the utility or cooperative has no telecommunications attachments. In contrast, fees calculated for other attachers under the formula are not reduced when municipal utilities and electric cooperatives attach telecommunications equipment in the space reserved for their electric attachments because the utility or cooperative is not allocated a share of the safety space and is not allocated any additional space for its telecommunications attachment.[265]

[265] Telephone interview with Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Yingying Ayliffe, managing attorney, office of general counsel, Tennessee Valley Authority, January 9, 2017.

Regardless of whether and where utilities and cooperatives attach their own telecommunications equipment, TVA predicts that implementing its formula will increase pole attachment fees charged by most of the region's utilities and cooperatives compared with current fees. According to TVA,

> based on a review of current pole attachment rates charged by [municipal utilities and electric cooperatives], the mid-point in the Valley is approximately $18. Applying the recommended methodology may result in a mid-point of approximately $30. Although most [utilities and cooperatives] are expected to see increased rates, some will see decreases from rates that are currently charged.[266] See appendix K.

The utilities and cooperatives that TVA serves are expected to begin using the formula by January 2017 for all new and renewal pole attachment contracts (with exceptions granted to January 2018 based on individual circumstances), but TVA will allow up to five years to phase the formula in, depending upon the level of variance between a municipal utility's or electric cooperative's current rate and the new rate applying TVA's approved methodology.[267]

The FCC's Formulas for Calculating Pole Attachment Fees

Federal law requires the FCC to use different formulas depending on whether the attacher is a cable television company or a telephone company. Like TVA's formula, both multiply a percentage based on the space allocated to each attaching entity by an estimate of the annual cost per pole. Although the FCC estimates annual pole costs in its cable formula the same way as TVA, it uses lower estimates in its telephone company formula to ensure that both of its formulas produce similar fees despite differences in the way they allocate space.[268] Both FCC formulas allocate less space to attachers than TVA's formula with the FCC's cable formula allocating the least.

The FCC's cable formula, like TVA's formula, estimates the annual cost per pole based on net pole investment, net investment for the overall utility plant, maintenance expenses for poles, administrative expenses and taxes for the overall utility plant, and depreciation reported in a utility's

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[266] Memorandum from John M. Thomas, III, executive vice president and chief financial officer, Tennessee Valley Authority, to Tennessee Valley Authority Board of Directors, January 22, 2016, https://www.tva.com/file_source/TVA/Site%20Content/About%20TVA/Guidelines%20and%20Reports/tva_determination_on_regulation_of_pole_attachments.pdf.

[267] Ibid.

[268] 47 US Code 224; 47 Code of Federal Regulations 1.1409; and Federal Communications Commission 2015c.

financial filings with FERC as well as return on investment.[269] Unlike TVA's formula, the FCC's cable formula calculates the space allocation percentage based on

1. the amount of space each entity's attachments actually require
2. divided by the amount of space used for all attachments, including space required to separate electric attachments from telecommunications attachments for worker safety.[270] See figure 4 and appendix L.

Figure 4. FCC Pole Attachment Fee Formula when Attacher is a Cable Company

$$Fee = \left(\frac{Space\ Occupied\ by\ Attacher}{Space\ Used\ for\ All\ Attachments}\right) \times (Est.\ Annual\ Pole\ Cost)$$

For telephone companies, the FCC guidelines use the greater fee calculated from two applications of a third formula that differ from each other only in how they estimate the annual pole costs to be allocated among the attaching entities. In both cases, the FCC's telephone formula multiplies an estimate of annual pole costs by a percentage of overall pole length allocated to each attaching entity based on

1. the amount of space each entity's attachments actually require and
2. two-thirds of the space on the pole below the minimum attachment height, including all of the pole that is buried underground, divided equally among all attachers
3. divided by overall pole length.[271] See figure 5 and appendix L.

Figure 5. FCC Pole Attachment Fee Formula when Attacher is a Telephone Company

$$Fee = \left(\frac{Space\ Occupied\ by\ Attacher + \frac{2}{3}\left(\frac{Space\ Below\ Lowest\ Attachment}{Total\ \#\ Attachers}\right)}{Total\ Pole\ Length}\right) \times (Est.\ Annual\ Pole\ Cost)$$

The first application of the FCC's telephone formula, like the TVA formula and the FCC cable formula, estimates the annual cost per pole based on net pole investment, net investment for the overall utility plant, maintenance expenses for poles, administrative expenses and taxes for the overall utility plant, and depreciation reported in a utility's financial filings with FERC as well as return on investment; however, it reduces this estimate by a percentage determined by the number of attachers.[272] Rather than reducing

[269] 47 Code of Federal Regulations 1.1409(e)(1) and 1.1404(g)(1)(x); Federal Communications Commission 1987; and Federal Communications Commission 2001.
[270] 47 Code of Federal Regulations 1.1409(e)(1).
[271] Federal Communications Commission 2015c.
[272] Federal Communications Commission 2015c; and Federal Communications Commission 2001.

the estimated annual pole cost by a set percentage, the second application excludes depreciation, taxes, and return on investment and estimates the annual pole cost based only on net pole investment, net investment for the overall utility plant, maintenance expenses for poles, and administrative expenses for the overall utility plant.[273] See appendix L.

Comparing Fees Calculated Using TVA's Formula with the FCC's Formulas

TVA's formula results in higher pole attachment fees than would be charged under the FCC's formulas for poles owned by for-profit entities. The differences can be several orders of magnitude. Applying TVA's formula to the example developed by the Authority in appendix K results in a fee of $21.11 per year for a telecommunications attacher using one foot of space on a pole with three total attachers. Applying the FCC's guidelines to the same example results in a fee of $5.50 per year for a cable company and $5.57 per year for a telephone company. See appendix M.

These differences result because TVA and the FCC have divergent goals when regulating pole attachments. TVA's statutory mandate is to provide its service area with electricity at rates as low as feasible.[274] According to the Authority,

> TVA seeks to ensure that electric systems are operated for the benefit of electric consumers and that electric rates are kept as low as feasible. Ensuring that [municipal utilities and electric cooperatives] are appropriately compensated for the use of electric system assets is important to achieving these goals. Importantly, failure to do so will have a direct impact on retail electric rates because electric ratepayers will be forced to subsidize the business activities of those entities that are utilizing electric system assets.[275]

In contrast, the FCC's formulas are based on its goal of "promoting consistent, cross-industry attachment rates that encourage deployment and adoption of broadband internet access services."[276]

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[273] 47 Code of Federal Regulations 1.1409(e)(2)(ii); and Federal Communications Commission 2001.

[274] 16 US Code 831; and email from Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, December 1, 2016.

[275] Memorandum from John M. Thomas, III, executive vice president and chief financial officer, Tennessee Valley Authority, to Tennessee Valley Authority Board of Directors, January 22, 2016, https://www.tva.com/file_source/TVA/Site%20Content/About%20TVA/Guidelines%20and%20Reports/tva_determination_on_regulation_of_pole_attachments.pdf.

[276] Federal Communications Commission 2015c.

TVA's formula and the FCC's formulas represent different approaches to allocating utility pole costs between pole owners and attachers without one unfairly subsidizing the other. Because these costs are ultimately passed on to customers, the question becomes how much of overall pole costs should be paid by a pole owner's customers and how much should be paid by each additional attacher's customers. Under the definition used in the Commission's 2007 report, neither TVA's formula nor the FCC's formulas result in unfair subsidies because they both produce fees that fall between the added annual costs to pole owners resulting from additional attachments and the costs to attachers of installing and maintaining their own poles.[277]

Limits on State Authority to Regulate Fees Charged by Municipal Utilities and Electric Cooperatives Served by TVA

TVA's recent action may prevent Tennessee from regulating pole attachment fees charged by municipal utilities and electric cooperatives. According to a 2014 opinion by the state's attorney general (appendix N), Tennessee likely would not be able to enforce pole attachment regulations that either

- cause municipal utilities and electric cooperatives to violate the power contracts they sign with TVA or
- infringe on TVA's authority as the sole regulator of retail electricity rates in its service area.

The opinion says that

> [r]egulation by the State of the rates, terms, and conditions of pole attachments of the TVA's distributors is not, currently, clearly preempted by the TVA Act, provided that State regulation does not affect either those distributors' rates for electric power or their ability to comply with their agreements with the TVA. *If the TVA were to assert its discretionary control over the rates and revenues of its distributors in a manner that directly affected pole attachments, regulation by the State would likely be preempted.*[278] (emphasis added)

TVA's authority as sole regulator of retail electricity rates for the utilities and cooperatives it serves is established under federal law.[279]

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[277] TACIR 2007.
[278] Tennessee Office of the Attorney General 2014b.
[279] 16 US Code 831i; Tennessee Electric Power Company et al. v. Tennessee Valley Authority et al. 306 U.S. 118 (1939); and John McCarthy et al. v. Middle Tennessee Electric Membership Corporation et al. 466 F.3d 399 (6th Cir. 2006).

Local regulation of public rights of way and zoning can affect whether providers are able to expand coverage.

Broadband is classified as an interstate service for regulatory purposes by the Federal Communications Commission. According to the FCC,

> as a general matter, mixed-jurisdiction services are typically subject to dual federal/state jurisdiction, except where it is impossible or impractical to separate the service's intrastate from interstate components and the state regulation of the intrastate component interferes with valid federal rules or policies. With respect to broadband Internet access services, the Commission has previously found that, "[a]lthough . . . broadband Internet access service traffic may include an intrastate component, . . . broadband Internet access service is properly considered jurisdictionally interstate for regulatory purposes."[280] (ellipses in original)

While classifying broadband as jurisdictionally interstate limits states' ability to regulate some aspects of service, such as the rates that providers charge subscribers,[281] it still provides state and local governments flexibility in matters related to zoning and public rights of way. According to the FCC, it has "long recognized the important responsibility of local and state governments to manage rights-of-way,"[282] and federal law "preserves state and local authority over zoning and land use decisions" for wireless broadband facilities.[283] But some restrictions still exist. As described in a 2011 article in St. John's Law Review,

> Section 253 of the [Federal Telecommunications Act] prohibits any state or local government from interfering with a telecommunications provider's ability to provide service, unless the state's regulation falls within one of the two safe harbor provisions. The first safe harbor provision allows state and local governments to "regulate telecommunications in the public interest, as long as such regulations are competitively neutral." The second safe harbor provision allows state and local "regulations relating to right-of-way management and compensation which are competitively neutral and nondiscriminatory."[284]

[280] Federal Communications Commission 2015e.
[281] Nuechterlein and Weiser 2013; and Federal Communications Commission 2015e.
[282] Federal Communications Commission 2002.
[283] Federal Communications Commission 2007.
[284] Lippert 2011.

Similarly, state and local zoning authority related to the siting of wireless broadband facilities is not absolute. According to Jonathan Nuechterlein, a lawyer who specializes in telecommunications law, and Philip Weiser, former dean of University of Colorado Law School,

> Section 332(c)(7)(B) of the [Federal Telecommunications Act], added in 1996, balances the interests of zoning authorities with those of wireless carriers by limiting the substantive bases on which localities can exclude transmission facilities from particular areas and permitting aggrieved parties to seek review in either federal or state court. This provision requires localities to base any denial of a siting request on "substantial evidence," an amorphous standard that, as one court explains, "requires balancing two considerations. The first is the contribution that the antenna will make to the availability of cellphone service. The second is the aesthetic or other harm that the antenna will cause. The unsightliness of the antenna and the adverse effect on property values that is caused by its unsightliness are the most common concerns. . . . But adverse environmental effects are properly considered also, and even safety effects: fear of adverse health effects from electromagnetic radiation is excluded as a factor, but not, for example, concern that the antenna might obstruct vision or topple over in a strong wind."[285] (ellipses in original)

Balancing the interests of providers and their customers with those of state and local governments is no small task. At the Commission's May 2016 meeting, representatives for providers said that local permitting processes can delay projects for months and zoning ordinances in some communities can, in effect, prohibit the construction of cell towers. Access to rights of way is also increasingly important for wireless providers because the next generation of wireless networks may rely on attaching transceivers to utility poles.[286] In a report produced along with its 2016 broadband survey, ECD says that slow permitting processes "can add uncertainty in the construction timeline as well as significant costs. Crews can sit idle while waiting for permitting approvals and this adds to the overall cost of construction."[287]

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[285] Nuechterlein and Weiser 2013.
[286] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016.
[287] Tennessee Department of Economic and Community Development 2016.

But controlling access to rights of way and regulating land use through zoning are vital local government functions, and once facilities are permitted and installed, they can be modified without government approval. For example, wireless facilities located in public rights of way can have their height increased by the greater of 10 feet or 10% of their current height and can have additional equipment attached to them as long as it doesn't protrude more than 6 feet from the original structure without local government approval.[288]

Streamlined Permitting and Broadband Ready Communities

Some states, including Indiana and Wisconsin, help local governments signal to providers that they have streamlined local permitting processes and removed other regulatory barriers to broadband investment. Indiana certifies communities as "broadband ready" if they

- appoint a single point of contact for all matters related to broadband development projects;
- allow for the electronic submission of all forms, applications, and documentation required for a broadband development project;
- require that all permit applications are approved or denied within 10 business days after they are filed;
- assure that all inspections related to a broadband project will be completed in a timely and expeditious manner; and
- adopt procedures that prohibit them from
    - » requiring the designation of a final contractor to complete a broadband project;
    - » imposing a fee to review an application or to issue a permit on a broadband project;
    - » imposing a seasonal moratorium on the issuance of permits for a project; and
    - » discriminating among communications service providers.[289]

According to the Indiana Economic Development Corporation,

> the Broadband Ready Community certification sends a signal to the telecommunication industry that a community has taken steps to reduce barriers to broadband infrastructure investment.
>
> While investment in broadband infrastructure is not guaranteed to follow once a community obtains the certification, reducing the regulatory hurdles that

[288] 47 Code of Federal Regulations 1.40001.
[289] Indiana Economic Development Corporation "Broadband Ready Communities."

> deter investment is a key step towards creating an environment ripe for broadband investment.[290]

Wisconsin has adopted a similar process for certifying communities as "Broadband Forward!" Just as in Indiana, eligible communities in Wisconsin must appoint a single point of contact for broadband projects and allow forms to be submitted electronically; they are also prohibited from imposing moratoria on new projects, discriminating among providers, and requiring applicants to designate a final contractor. In Wisconsin, applications must be approved or denied within 60 days, and unlike Indiana, communities can collect permitting fees as long as they are reasonable and application fees as long as they don't exceed $100. Further, communities are prohibited from conditioning approval on government access to the network.[291]

Dig Once Policies

In addition to discussing the benefits of streamlined permitting, ECD says that so-called dig once policies can facilitate construction of broadband infrastructure. According to ECD,

> policies that encourage placement of conduit or fiber optic cable when a trench is open eliminate much of the capital costs for network deployment. By coordinating with other City, County or State capital projects such as sidewalk improvements, establishment of trails, implementation of street lighting, road construction and road widening projects, additional conduit can be placed within the trench when other work is being performed in the right of way. Coordination with other utility projects can substantially decrease the costs of broadband infrastructure.
>
> A ***Dig Once Policy*** typically has the following components:
>
> - All public works or installation of other telecom, cable or utility infrastructure allows for conduit to be placed on behalf of the local or State government and any other entities that want to participate. If there is an open trench, the policy provides for coordination of street cuts and excavations with utilities, public works, developers and other interested parties.

[290] Ibid.
[291] Wisconsin Revised Statutes 196.504(4).

> This maximizes the opportunity for broadband-specific conduit installation, while minimizing cost, community disruption and damage to existing infrastructure.
>
> - A notice period informing other entities that an open trench will be available for placement of their conduit and/or fiber optic facilities.
>
> - Allows for shadow conduit to be placed on behalf of the local and/or State government. The installation of empty and/or spare conduit by a public agency when excavations occur in the public right of way, with agency (Town, City or County) costs limited to the incremental costs of the conduit only. . . .
>
> Additionally, various government agencies can establish ***Joint Trench Agreements*** and ***Joint Build Agreements*** with other telecommunications, cable or utility providers. Cost for placement of conduit or fiber will be shared amongst all entities, allowing each to take advantage of the other's trenching. Standardization of these agreements across all potential owners of underground infrastructure can be established to ensure all parties are aware of the joint trenching opportunities as they become available.[292]

There is a dig once provision already in Tennessee law, though it only applies in areas of new construction or property development. Tennessee Code Annotated, Section 7-59-310(b), requires municipalities, counties, and other permitting authorities to condition the issuance of permits for open trenching in cases of new construction or property development where utilities are to be placed underground on the developer or property owner providing notice to all cable television providers so that they can place their equipment in the trench while it is open. If notice is not given, the developer or property owner is responsible for the cost of new trenching.

One Touch Make Ready

ECD also says that one-touch make-ready processes can help streamline the expansion of coverage. Traditionally, when a new attacher wants to place its equipment on a utility pole, all existing attachers are notified and move their own equipment one-by-one to accommodate the new attachment.

[292] Tennessee Department of Economic and Community Development 2016.

One-touch make-ready policies allow a pole owner to designate a single contractor to move all existing attachments at once. According to ECD,

> one of the most unpredictable and costly components of fiber optic construction is the "make-ready" process. "Make-ready" refers to the inspections, engineering, and rearrangements necessary to accommodate the installation of multiple cables on a utility pole. Make-ready engineering for placement of fiber optic cables needs to comply with the National Electric Safety Code (NESC). Compliance may include moving existing fiber optic cable, increasing the load bearing ability of poles and/or the transfer or replacement of existing poles required to accommodate the attachment of new fiber optic cable. At times, the make-ready process can require multiple companies to dispatch crews with specialized equipment and bucket trucks to move their physical attachments on the communications portion of utility poles, causing slowdowns and duplicate expenses for deployments.
>
> In order to better streamline this time consuming and high-cost element, a ***One-touch Make-Ready Process*** or ***One Truck-Roll Procedure*** can be established to enable and encourage all of this work to be done by one company rather than by many.[293]

Louisville, Kentucky, and Nashville have both adopted one-touch make-ready ordinances, but providers have sued to block their enforcement in both cases. In its initial complaint against Nashville filed in the US District Court for the Middle District of Tennessee, AT&T says that the city's one-touch make-ready ordinance

> deprive[s] [AT&T] of an adequate opportunity to assess the potential for network disruption caused by the alteration or relocation, and to specify and oversee the work on AT&T's own facilities to ensure any potential for harm to its network, including harm to the continuity and quality of service to its customers, is minimized.
>
> The Ordinance also permits an Attacher to rearrange AT&T facilities on [Nashville Electric Service (NES)] poles without regard to AT&T's standards for work on its facilities. Within thirty days after completing the

[293] Ibid.

> work, the Attacher must notify AT&T of the work on AT&T's facilities. AT&T then has sixty days to inspect the work, and if it does not meet NES standards, AT&T can demand the work be corrected at the Attacher's expense. Further, the Attacher must indemnify NES for any claims made by AT&T, but it is not required to indemnify AT&T for any harm resulting from the work on AT&T's facilities.[294]

AT&T says in its complaint that the ordinance conflicts with the FCC's pole attachment regulations. According to AT&T,

> [t]he pole attachment rights and obligations created by the Ordinance are a drastic departure from, and conflict with, those set forth in federal regulations promulgated by the Federal Communications Commission. The federal Communications Act authorizes the FCC to "regulate the rates, terms, and conditions for pole attachments to provide that such rates, terms, and conditions are just and reasonable," and it directs the FCC to "prescribe by rule regulations to carry out the provisions of this section." 47 U.S.C. § 224(b)(1), (2).
>
> Under the FCC's regulations, an entity with existing attachments, including AT&T, is entitled to prior written notice in the event any make-ready work would affect the entity's facilities. 47 C.F.R. § 1.1420(e). Under the FCC's regulations, the entity with existing attachments, including AT&T, has up to 60 days (and potentially more, depending upon the type of facilities and size of the order) to modify its attachments to accommodate a new attacher. 47 C.F.R. § 1.1420(e). Further, under the FCC's regulation, a new attacher may hire a contractor to complete the make-ready work itself only if the work has not been completed by the specified deadline. 47 C.F.R. § 1.1420(i).[295]

But the FCC's pole attachment regulations for the make-ready process, much like its regulations for pole attachment fees, only apply to poles owned by for-profit companies.[296] TVA does not regulate the make-ready

[294] Bell South Telecommunications, LLC, v. Metropolitan Government of Nashville and Davidson County, Tennessee, et al. Complaint for Declaratory Relief and Injunctive Relief in the US District Court for the Middle District of Tennessee, September 22, 2016.
[295] Ibid.
[296] 47 Code of Federal Regulations 1.1402(a).

process for poles owned by the municipal utilities and electric cooperatives it serves, only pole attachment fees.[297]

In Nashville, utility poles owned by for-profit entities like AT&T—approximately 20% of poles in the city—are subject to the FCC's make-ready regulations because Tennessee has not opted out of them, unlike Kentucky. But the FCC, in a statement of interest filed on its behalf by the US Department of Justice in AT&T's lawsuit against Louisville, Kentucky, says that one-touch make-ready policies generally do not conflict with the FCC's regulations. According to the FCC,

> [h]istorically, restrictions on access to utility poles have been a significant impediment to the deployment of competitive telecommunications services. The Commission has repeatedly recognized that "lack of reliable, timely, and affordable access to physical infrastructure—particularly utility poles—is often a significant barrier to deploying wireline and wireless services." As recently as 2011, the Commission found "pervasive and widespread problems of delays in survey work, delays in make-ready performance, delays caused by a lack of coordination among existing attachers, and other issues" that create significant obstacles for new attachers.
>
> One frequent source of delay in deploying new pole attachments involves "make-ready" work, which generally consists of moving or rearranging existing wires and attachments to make space for new attachments. These delays can be caused not only by pole owners, but also by "'existing attachers' action (or inaction) to move equipment to accommodate a new attacher, potentially a competitor.'" "[E]xisting attachers . . . have little incentive to cooperate, especially if the applicant will be a competitor, and this constrains the[] ability to provide timely pole access to new attachers." And in many cases, the pole owner is itself a telecommunications provider that competes with—and therefore has incentive to impede or discriminate against—new attachers seeking access to the pole.

[297] Interview with Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, November 3, 2016.

Recognizing the critical importance of timely access to utility poles for new attachers, the Commission held in the *2010 Pole Attachment Order* that "access to poles, including the preparation of poles for attachment, commonly termed 'make-ready,' must be timely in order to constitute just and reasonable access. . . . Make-ready or other pole access delays not warranted by the circumstances thus are unjust and unreasonable under section 224." In 2011, the Commission promulgated a rule "set[ting] a date for completion of make-ready that is no later than 60 days after" a request for attachment is accepted and payment received (subject to certain exceptions). . . .

As a general matter, promoting the deployment of competitive broadband infrastructure through one-touch make-ready policies is consonant with the goals of federal telecommunications policy, the Communications Act, and applicable FCC regulations.

Congress's stated goal in enacting the Telecommunications Act of 1996, which comprehensively reformed and amended the original Communications Act of 1934, was to establish a "national policy framework designed to accelerate rapidly private sector deployment of advanced telecommunications and information technologies and services to all Americans by opening all telecommunications markets to competition." Consistent with this goal, Congress directed the Commission in Section 706 of the Telecommunications Act to "encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans" and, if this goal is not being met, to "take immediate action to accelerate the deployment of such capability by removing barriers to infrastructure investment and by promoting competition in the telecommunications market."

One-touch make-ready policies directly advance these goals. Ensuring "reliable, timely, and affordable access to physical infrastructure—particularly utility poles," encourages the timely deployment of advanced telecommunications services to all Americans. As recognized in the *National Broadband Plan*, one-touch make-ready policies seek to alleviate "a significant

> source of costs and delay in building broadband networks" by "lower[ing] the cost of the make-ready process and speed[ing] it up." ("The cost of deploying a broadband network depends significantly on the costs that service providers incur to access conduits, ducts, poles and rights-of-way"). "These cost-saving steps can have an immediate impact on driving fiber deeper into networks, which will advance the deployment of both wireline and wireless broadband services," removing barriers to investment, promoting competition, and ensuring timely deployment of advanced telecommunications capability to all Americans.[298] (citations omitted)

AT&T also alleges that Nashville's one-touch make-ready ordinance "constitutes a substantial and unconstitutional impairment of AT&T's contract with Metro Nashville" and that Metro Nashville's charter does not give it the authority to regulate the terms and conditions of attachments on poles owned by Nashville Electric Service.[299] Metro-Nashville disputes these additional claims in its memorandum supporting its motion to dismiss AT&T's complaint.[300]

Tennessee law currently places restrictions on municipal electric systems and electric cooperatives.

Tennessee currently places restrictions on municipal electric systems and electric cooperatives that provide broadband. While municipal electric systems are authorized to provide broadband within their electric service territories, electric cooperatives can provide broadband only in unserved areas as part of a partnership with another provider that has a local or state issued cable franchise. Other restrictions, both in state law and in the contracts for wholesale electricity that Tennessee's municipal utilities and electric cooperatives sign with TVA, prohibit them from using electric ratepayer revenue to subsidize broadband service. In recent years, bills have been proposed to remove the territorial restriction on municipal utilities, though none have advanced in the General Assembly.

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[298] Bell South Telecommunications, LLC, v. Louisville/Jefferson County Metro Government et al. Statement of Interest of the United States in the US District Court for the Western District of Kentucky, October 31, 2016.

[299] Bell South Telecommunications, LLC, v. Metropolitan Government of Nashville and Davidson County, Tennessee, et al. Complaint for Declaratory Relief and Injunctive Relief in the US District Court for the Middle District of Tennessee, September 22, 2016.

[300] Bell South Telecommunications, LLC, v. Metropolitan Government of Nashville and Davidson County, Tennessee, et al. Defendants' Memorandum of Law in Support of Motion to Dismiss Plaintiff AT&T's Complaint in the US District Court for the Middle District of Tennessee, November 14, 2016.

Municipal Electric Systems

Tennessee is one of almost 30 states that place at least some restrictions on municipalities that provide broadband service. Of these, Texas prohibits municipalities from providing broadband, and four states—Nebraska, Nevada, Utah, and Washington—only authorize municipalities to provide broadband as wholesalers to retail providers or have laws that have the effect of restricting municipalities to wholesale service. Common restrictions that other states, like Tennessee, place on municipal providers include territorial limitations, prohibitions against subsidizing the cost of service, and requirements that municipalities produce cost-benefit analyses as well as hold referenda, public hearings, or both before providing service.

Municipalities with electric systems are authorized to provide broadband within their electric service areas by Tennessee Code Annotated, Section 7-52-601 et seq. Of the 56 municipal electric systems in the state, 10 currently provide broadband—Bristol, Chattanooga, Clarksville, Columbia, Erwin, Fayetteville, Jackson, Morristown, Pulaski, and Tullahoma. Two other municipal electric systems—Covington and Memphis—built broadband networks in the past but have since sold them.

Before Providing Service: Business Plans, Public Hearings, and Local Approval

Before providing broadband under Tennessee Code Annotated, Section 7-52-601 et seq., municipal electric systems must submit business plans, including a three-year cost-benefit analysis, to the Tennessee Comptroller of the Treasury.[301] The Comptroller's Office reviews these plans and provides utilities with comments. Although not required under state law, TVA also reviews some electric systems' broadband business plans, but only those that call for a utility's electric division to make loans to its broadband division, and then, only to determine whether the proposed plan is likely to result in repayment of the loan.[302]

The reviews conducted by the Comptroller's Office and TVA, however, are only advisory; the final decision on whether to provide service is made at the local level.[303] Tennessee Code Annotated, Section 7-52-602, requires a public hearing to be held after which a municipal electric system may begin providing broadband only after approval by a two-thirds majority vote of the chief legislative body of the municipality in which it is located

[301] Tennessee Code Annotated, Section 7-52-602.

[302] Interview with Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, November 3, 2016; and email from Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, December 1, 2016.

[303] Panel discussion of regulatory landscape for broadband providers, TACIR, May 26, 2016; and interview with Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, November 3, 2016.

or, upon a simple majority vote of the chief legislative body in favor of a referendum, by a public referendum of the municipality's registered voters.[304]

Prohibition Against Subsidies and Requirements for Payments in Lieu of Taxes

Municipal electric systems are prohibited from subsidizing broadband service with revenue from electric ratepayers or other utility operations under Tennessee Code Annotated, Section 7-52-603. These electric systems must establish separate broadband divisions, and the costs of providing broadband must be fully allocated to them. While electric systems are authorized to loan money from their electric divisions to their broadband divisions, these loans must be at a rate of interest at least equal to the highest rate earned by the electric system on its invested funds.

Municipal electric systems are also required to make payments in lieu of taxes for ad valorem property taxes following a formula applied to their electric divisions. These payments are capped at what the electric system would owe if it were a private provider. Further, electric systems must make payments in lieu of franchise and excise taxes, sales taxes, and local privilege taxes to the same extent as if they were for-profit providers.[305] Currently, for-profit providers do not remit sales taxes on internet service or pay local privilege taxes related to providing internet service, which are calculated as a percentage of sales, because federal law prohibits the sale of internet service from being taxed.[306]

Both the Tennessee Comptroller of the Treasury and the Tennessee Valley Authority provide oversight of municipal electric systems that offer broadband in Tennessee. Municipal electric systems are required to submit annual audits performed by certified public accountants to the Tennessee Comptroller of the Treasury. The Comptroller's Office reviews these audits for compliance with Generally Accepted Accounting Principles and Generally Accepted Government Accounting Standards. Evidence that a municipal electric system is subsidizing broadband service with electric revenues or not making appropriate payments in lieu of taxes would be reported as a finding, but according to the Comptroller's Office, it does not have enforcement authority to correct violations.[307]

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[304] Tennessee Code Annotated, Section 7-52-602(3), (4), and (5).
[305] Tennessee Code Annotated, Section 7-52-606.
[306] US Public Law 114-125, Section 922; and interview with Barbara Sampson, assistant commissioner, Tennessee Department of Revenue, and Sherry Hathaway, tax policy and development manager, Tennessee Department of Revenue, April 7, 2016.
[307] Interview with Jerry Durham, assistant director, division of local audit, Tennessee Comptroller of the Treasury, and Jean Suh, contract audit review manager, division of local audit, Tennessee Comptroller of the Treasury, September 1, 2016.

TVA provides oversight of municipal electric systems that offer broadband in Tennessee through its authority under federal law[308] as the sole regulator of retail electricity rates in its service area. Provisions in the contracts for wholesale electric power that municipal electric systems sign with TVA prohibit them from using electric ratepayer revenue to subsidize broadband service. According to TVA, these power contracts require municipalities to establish and maintain separate funds for their electric systems and establish both the purposes for which electric ratepayer revenue may be used and the order in which revenue may be used for those purposes. Provisions common to TVA's wholesale power contracts include:

> **1. Purpose of Contract.** It is hereby recognized and declared that, pursuant to the obligations imposed by the TVA Act, Municipality's operation of a municipal electric system and TVA's wholesale service thereto are primarily for the benefit of the consumers of electricity. Toward that end, Municipality agrees that the electric system shall be operated on a nonprofit basis, and that electric system funds and accounts shall not be mingled with other funds or accounts of Municipality. Municipality may, as hereinafter provided, receive from the operation thereof for the benefit of its general funds only an amount in lieu of taxes representing a fair share of the cost of government properly to be borne by such system. In accordance with these principles, which are mutually recognized as of the essence of this contract, Municipality agrees that the electric system shall be operated and the system's financial accounts and affairs shall be maintained in full and strict accordance with the provisions of this contract.
>
> **6. Use of Revenues.**
>
> (a) Municipality agrees to use the gross revenues from electric operations for the following purposes:
>
> (1) Current electric system operating expenses, including salaries, wages, cost of materials and supplies, power at wholesale, and insurance;
>
> (2) Current payments of interest on System Indebtedness, and the payment of principal amounts, including sinking fund payments, when due;

[308] 16 US Code 831i; Tennessee Electric Power Company et al. v. Tennessee Valley Authority et al. 306 U.S. 118 (1939); and John McCarthy et al. v. Middle Tennessee Electric Membership Corporation et al. 466 F.3d 399 (6th Cir. 2006).

> (3) From any remaining revenues, reasonable reserves for renewals, replacements, and contingencies; and cash working capital adequate to cover operating expenses for a reasonable number of weeks; and
>
> (4) From any revenues then remaining, tax equivalent payments into Municipality's general funds, as more particularly provided in section 2 of the Schedule of Terms and Conditions hereinafter referred to.
>
> (b) All revenues remaining over and above the requirements described in subsection (a) of this section shall be considered surplus revenues and may be used for new electric system construction or the retirement of System Indebtedness prior to maturity; provided, however, that resale rates and charges shall be reduced from time to time to the lowest practicable levels considering such factors as future circumstances affecting the probable level of earnings, the need or desirability of financing a reasonable share of new construction from such surplus revenues, and fluctuations in debt service requirements.[309]

TVA's wholesale power contracts also contain specific terms and conditions related to electric system revenues and accounting, according to TVA staff:

> **1. Financial and Accounting Policy.** Municipality agrees to be bound by the following statement of financial and accounting policy:
>
> (a) Except as hereinafter provided, Municipality shall administer, operate, and maintain the electric system as a separate department in all respects, shall establish and maintain a separate fund for the revenues from electric operations, and shall not directly or indirectly mingle electric system funds or accounts, or otherwise consolidate or combine the financing of the electric system, with those of any other of its operations. The restrictions of this subsection include, but are not limited to, prohibitions against furnishing, advancing, lending, pledging, or otherwise diverting electric system funds, revenues, credit or property to other operations of Municipality, the purchase or payment of, or providing

[309] Email from Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, November 14, 2016.

security for, indebtedness or other obligations applicable to such other operations, and payment of greater than standardized or market prices for property or services from other departments of Municipality. In the interest of efficiency and economy, Municipality may use property and personnel jointly for the electric system and other operations, subject to agreement between Municipality and TVA as to appropriate allocations, based on direction of effort, relative use, or similar standards, of any and all joint investments, salaries and other expenses, funds, or use of property or facilities.

(b) Municipality shall keep the general books of accounts of the electric system according to the Federal Energy Regulatory Commission Uniform System of Accounts. Municipality shall allow the duly authorized agents of TVA to have free access at all reasonable times to all books and records relating to electric system operations. TVA may provide advisory accounting service, in reasonable amount, to help assure the proper setting up and administering of such accounts.

(c) Municipality shall supply TVA not later than August 15 of each year with an annual financial report in such form as may be requested, of electric system transactions for the preceding year ending June 30 and of electric system assets and liabilities as of June 30. Municipality shall furnish to TVA such printed operating, statistical, and financial reports relating to electric system monthly operations as may reasonably be requested by TVA. Such monthly reports to TVA should be submitted not later than 30 days after each calendar monthly end. (Where information relating to such statistical reports is maintained on computers Municipality will also provide such statistical report information by a computer medium, working with TVA in developing a satisfactory format.) In the event of failure by Municipality to furnish promptly any such reports, TVA, following written notification to Municipality of intention to do so, may with its own staff perform at Municipality's expense all work necessary to collect and process the data necessary to provide the information that should have been furnished in the reports.

(d) Municipality shall have the electric system financial statements examined annually by independent certified

> public accountants in accordance with generally accepted auditing standards. A copy of the audit report and any related letters to Municipality from the certified public accountants shall be provided to TVA. These documents should be provided to TVA not later than October 31 of each year.[310]

Municipal electric systems are required to enter joint cost allocation agreements with TVA to ensure that costs are properly allocated among their different divisions. According to TVA, divisions that use assets, such as fiber-optic cables, owned by another division must pay the division that owns the assets for their use or for services provided in accordance with formulas agreed to in these joint cost allocation agreements.[311]

Much like the Comptroller's Office, TVA requires the municipal electric systems it serves to submit annual audits performed by independent certified public accountants. TVA reviews each electric system's audit every year. In addition to its annual audit review, TVA performs compliance assessments on each utility every few years. According to TVA, these assessments include a review of an electric system's accounts to ensure compliance with its joint cost allocation agreement. If TVA finds that a utility is using electric system funds to subsidize broadband service, it can require repayment of those funds. Because it is the sole regulator of retail electric rates for the utilities it serves, TVA can also refuse requests for electric rate increases from these utilities if they are not in compliance with their joint cost allocation agreements.[312]

Any loans from a municipal electric system's electric division to its broadband division must be approved by TVA. According to TVA, loan terms and conditions are spelled out in interdivisional loan agreements to ensure both that these loans provide reasonable protections for electric ratepayers in case of default and that they don't amount to subsidies. TVA reviews whether repayments of principal and interest are being made in accordance with interdivisional loan agreements both in its compliance assessments and its review of utilities' annual audits. If a utility is not in compliance, TVA can renegotiate the loan agreement and refuse any rate increases for that utility's electric division until necessary repayments

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[310] Ibid.

[311] Interview with Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, November 3, 2016.

[312] Ibid.

are made. While terms and conditions can be amended, loans cannot be written off.[313]

Territorial Restriction

Municipal electric systems are authorized to provide broadband only within their electric service territories under Tennessee Code Annotated, Section 7-52-601, except for Morristown and Covington, which are also authorized to provide service anywhere in the counties in which they are located. There have been several recent efforts to eliminate this territorial restriction for all of Tennessee's municipal electric systems. While most of these have called for legislation at the state level, Chattanooga's municipal electric system—Electric Power Board of Chattanooga (EPB)—sought federal help overturning the state's law.

EPB petitioned the FCC to preempt Tennessee's territorial restriction in July 2014. EPB was joined by the city of Wilson, North Carolina, which sought to overturn that state's territorial restriction as well as several other restrictions. The FCC granted both petitions in an order adopted in February 2015, but Tennessee and North Carolina sued to overturn it in federal court. In August 2016, the US Court of Appeals for the 6th Circuit ruled in the states' favor and reversed the FCC's order.[314]

Multiple bills in recent legislative sessions of the Tennessee General Assembly have also addressed the state's territorial restriction on municipal broadband providers, including two in the 109th General Assembly. Senate Bill 1134 by Senator Janice Bowling and House Bill 1303 by Representative Kevin Brooks would have removed the territorial restriction entirely. Another bill, Senate Bill 1990 by Senator Mike Bell and House Bill 1839 by Representative Jeremy Durham, would have allowed municipal electric systems to provide broadband outside of their electric service territories but only in areas not eligible for Connect America Fund support and where no other provider offers service of at least 25/3.

Proponents of eliminating Tennessee's territorial restriction say that municipal electric systems will expand coverage to unserved and underserved areas of the state if authorized to do so.[315] Proponents also say that municipal broadband providers can improve competition in communities that already have broadband if they are authorized to expand

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[313] Email from Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, August 24, 2016; and interview with Jennifer Brogdon, director, regulatory assurance, Tennessee Valley Authority, and Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, November 3, 2016.

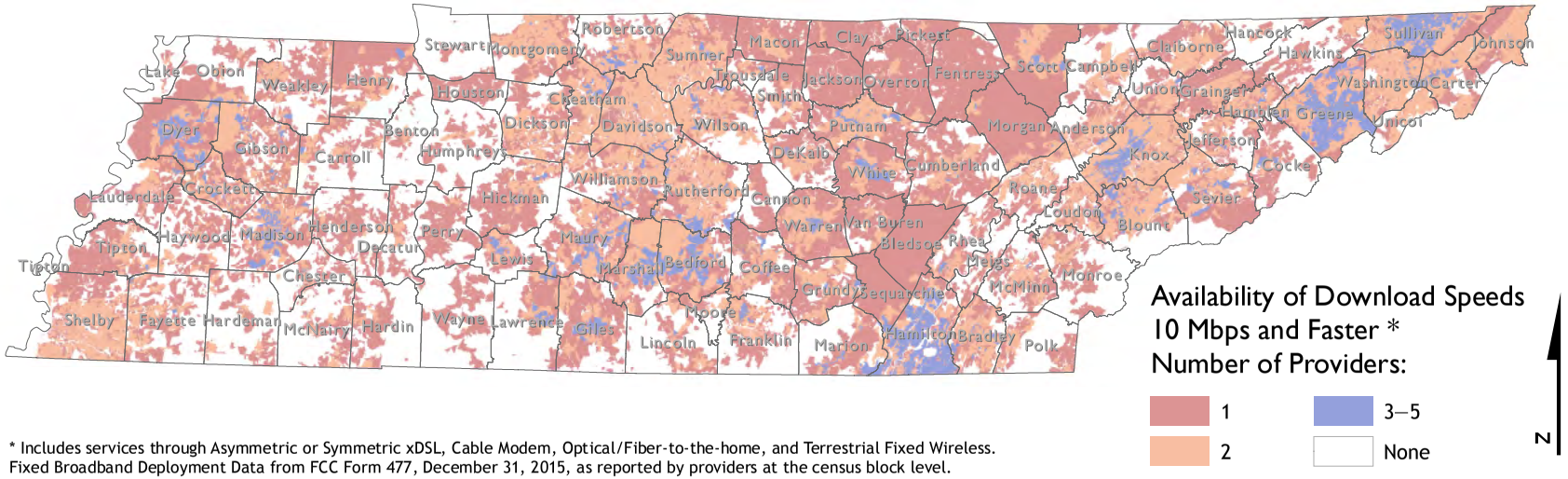
[314] Federal Communications Commission 2015b; and State of Tennessee et al. v. Federal Communications Commission et al. 832 F.3d 597 (6th Cir. 2016).

[315] Schelzig 2016.

outside their electric service areas.[316] According to the FCC, other providers in Chattanooga either stabilized or lowered their rates after EPB began offering broadband, though the FCC does not include evidence of a direct causal link. Providers in Chattanooga also made investments to improve their networks' overall speeds.[317] Providers in other cities have similarly reduced their rates and improved overall speeds after new for-profit competitors either entered or announced plans to enter their markets.[318] Approximately 71% of Tennesseans live in census blocks where at least two providers reported offering wireline or fixed wireless broadband of 10/1 or better as of December 2015, but only 23% live in blocks where at least two providers reported offering 25/3 or better. Access to more than two providers is limited for both 10/1 and 25/3 service. Approximately 13% of Tennesseans live in census blocks where three or more providers reported offering wireline or fixed wireless broadband of at least 10/1, and less than 3% live in blocks where three or more providers reported offering at least 25/3.[319] See maps 3 and 4 and appendixes O and P.

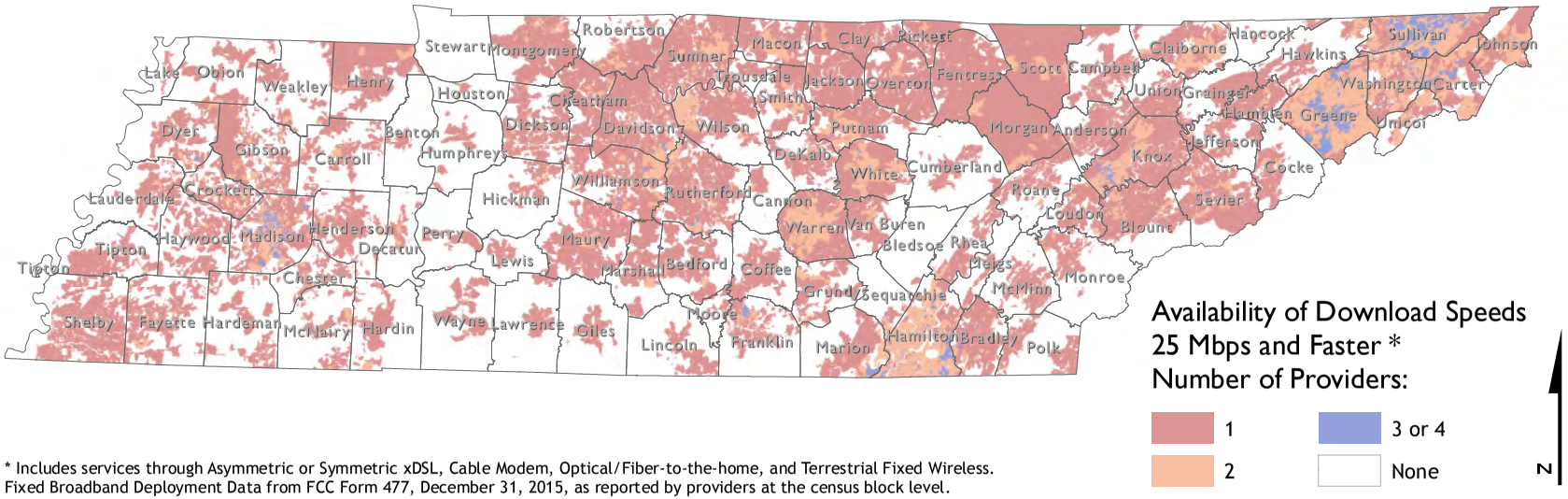
[316] Federal Communications Commission 2015b.
[317] Ibid.
[318] Brodkin 2015a; and McGee 2015.
[319] TACIR staff calculations using FCC Form 477 data reported as of December 31, 2015, and population data from 2010 census.

Map 3. Number of Providers Reporting Download Capacities of At Least 10 Megabits per Second for Wireline and Fixed Wireless Service as of December 2015.



* Includes services through Asymmetric or Symmetric xDSL, Cable Modem, Optical/Fiber-to-the-home, and Terrestrial Fixed Wireless.
Fixed Broadband Deployment Data from FCC Form 477, December 31, 2015, as reported by providers at the census block level.

Map 4. Number of Providers Reporting Download Capacities of At Least 25 Megabits per Second for Wireline and Fixed Wireless Service as of December 2015.



* Includes services through Asymmetric or Symmetric xDSL, Cable Modem, Optical/Fiber-to-the-home, and Terrestrial Fixed Wireless.
Fixed Broadband Deployment Data from FCC Form 477, December 31, 2015, as reported by providers at the census block level.

But even without the current territorial restriction, cost is still a barrier for municipal electric systems that could prevent them from expanding broadband service in some areas. Morristown Utilities—one of two systems authorized to provide broadband outside its electric service area—has only expanded service to a few communities. The utility provides electric service within the city limits of Morristown, and its broadband network has been built out to all of its electric customers, though not all subscribe to broadband service. While Morristown Utilities is authorized to provide broadband throughout Hamblen County outside its electric service area, the cost of performing make-ready work to attach equipment on utility poles is too high, especially in areas that are already developed, according to representatives from the utility. Moreover, the utility is reluctant to use bonds backed by city taxpayers to finance the expansion of its broadband network in the county, and the county has so far not agreed to back bonds itself.[320]

Like Morristown, many of the municipal electric systems in Tennessee that provide broadband have financed their networks using bonds backed either by revenue from electric ratepayers or municipal taxpayers. If broadband revenue isn't enough to make payments on these bonds, electric ratepayers or municipal taxpayers shoulder the risk of repaying them, even if a network is sold. For example, Provo, Utah, built a network for providing wholesale broadband service, but the retail provider that the city partnered with did not generate enough revenue for the city to make its debt payments. In 2013, Provo sold its $39 million network to Google for $1, but city taxpayers are still responsible for paying off nearly $40 million in debt related to the system.[321] Similarly, Groton, Connecticut, built a network for providing retail broadband but sold it for $550,000 in 2013, less than ten years after beginning service. The $27.5 million in debt remaining after the sale of the network will be repaid by Groton Utilities, the city's electric and water utility.[322] Those living outside an electric system's electric service area or outside its municipality's tax jurisdiction don't share in these risks, though they may benefit from an electric system expanding its network outside its electric service area. While utilities can justify bonds for providing broadband inside their electric service areas at least in part based on the benefits to electric ratepayers that can result from the construction of communications networks that support management and operation of the electric grid, this dual justification doesn't exist for utilities providing broadband outside their electric service areas.

[320] Telephone interview with Clark Rucker, chief financial officer, Morristown Utilities, August 8, 2016; and telephone interview with Jody Wigington, general manager and chief executive officer, Morristown Utilities, October 21, 2016.
[321] Davidson and Santorelli 2014.
[322] Ibid.

Municipally-owned broadband networks are not immune from risks that all providers face in competitive markets. According to New York Law School professors Charles Davidson and Michael Santorelli,

> for policy makers considering whether to pursue a [government-owned network (GON)], the failed and failing GONs offer a more instructive perspective about the complexities and challenges of building and deploying advanced communications networks than the apparent successes do.
>
> First, municipal networks viewed as successful generally had their genesis in unique circumstances that are extremely difficult to replicate. The gigabit network in Chattanooga, for example, benefited immensely from a one-time $111 million federal grant that was part of a much larger policy response to the Great Recession. This allocation, which was substantially larger on a per capita basis than any other smart grid-related grant made by the federal government, enabled the municipal utility to "build its [fiber-optic communications] system in three years instead of 10." Similarly, the GON in Bristol, Virginia, benefited from the infusion of tens of millions of dollars in grants from the state's Tobacco Commission. In addition, historically low interest rates enabled some municipalities to either refinance outstanding GON debt or issue new bonds with even lower rates. These conditions are unlikely to persist over the long term: interest rates, even on municipal bonds, are expected to begin rising soon, and public funding of all kinds is likely to be cut back substantially in response to calls for deficit reduction and balancing budgets.
>
> Second, many initial successes have not endured. Thus, using a particular municipal broadband project as a model for other cities to replicate should be undertaken with caution. As discussed in section 2, municipal Wi-Fi advocates immediately pointed to troubled projects in cities like Philadelphia when making the case for similar projects in other cities. Many of these networks failed, though, either in the near term (e.g., as in Philadelphia and Orlando) or over the long term (e.g., a city Wi-Fi network in Seattle, Washington, was shut down in 2012; policy makers in Riverside, California, are seriously considering cancelling its municipal service). Similar enthusiasm abounded during initial deployment of

> GONs that eventually faltered in places like Burlington, Vermont; Dunnellon, Florida; Monticello, Minnesota; Quincy, Florida; and the many cities that make up the UTOPIA consortium. Some of these systems were seen as strong evidence that "communities can build a telecommunications network to provide better services at a lower cost while raising revenue." And it appears that support for these systems as possible models for other cities interested in pursuing a GON has persisted even after it became clear these networks failed or were beginning to fail.
>
> Third, for policy making purposes, it is notable that many of the reasons for failure tend to be similar. As discussed in section 4.1, many GONs have been plagued with high levels of debt and low levels of consumer demand for and use of municipal broadband services. These two core factors undermine many municipal broadband networks. Such was the case in Groton, Provo, UTOPIA, Dunnellon, Quincy, Monticello, and numerous other cities. These problems were compounded by the local government's general inability to keep pace with other ISPs in the broadband market.[323]

In Tennessee, municipal electric systems in Covington and Memphis both developed broadband networks but later sold them because they did not generate enough revenue. Covington Electric Service—one of the two municipal electric systems authorized to provide broadband outside its electric service area—began providing broadband in 2002, using general obligation bonds to finance construction of its network. But the system did not generate enough revenue through cable and internet service, and it was sold to a private provider in 2007, following the failure of a referendum on whether to raise property taxes to support continued operation of the network.[324] Memphis Light Gas and Water (MLGW) partnered with private investors to build a fiber-optic network, which began operations in 2001, for providing wholesale broadband to retail providers. The partnership—Memphis Networx—had difficulty convincing established retail broadband providers to use its network to offer service. In 2007, the network was sold at a loss to MLGW of $29 million.[325]

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[323] Ibid.

[324] Telephone interview with Tim Slaee, general manager, Covington Electric System, November 12, 2015; and Memphis Business Journal 2007.

[325] Telephone interview with Dana Jeanes, chief financial officer, Memphis Light Gas and Water, November 20, 2015; and Davis 2007.

There are, however, ten municipal electric systems currently providing broadband in Tennessee. Some, such as EPB, have won grants to help finance their networks.[326] All have taken on debt either in the form of bonds, loans, or both. Table 7 shows the long-term debts attributed to the broadband divisions of these municipal utilities, including loans from the utilities' electric divisions. For accounting purposes, debts taken out to build broadband assets, such as fiber-optic cables, are only carried on the books of the division that owns them. As noted above, divisions that use assets owned by another division, such as broadband divisions that use fiber-optic cables owned by utilities' electric divisions, must make lease payments for using these assets. In many cases, the debts of these utilities' broadband divisions were and are substantial, demonstrating both the high up-front costs of building broadband networks and the lag between when a network is built and the intake of revenue to pay for it. But as their numbers of subscribers have increased, the remaining debts of these utilities' broadband divisions have generally decreased (see tables 7 and 8). Similarly, all showed positive changes in net position for fiscal year 2015 with the exception of Erwin Utilities, which only began providing service that year (see table 9).

Table 7. Municipal Broadband Providers in Tennessee: Long-Term Debt of Broadband Divisions Including Inter-Divisional Loans Fiscal Years 2010-11 through 2014-15

	2010-11	2011-12	2012-13	2013-14	2014-15
Bristol*	$ 2,194,132	$ 3,311,397	$ 1,223,297	$ -	$ -
Chattanooga*	65,234,000	67,658,000	70,631,000	53,463,000	43,795,000
Clarksville*	17,935,096	17,717,744	17,766,687	17,600,881	17,296,708
Columbia	12,369,029	11,704,239	11,122,077	10,488,601	9,737,477
Erwin	NA	NA	NA	NA	225,000
Fayetteville	6,124,629	4,936,762	4,137,744	3,454,709	2,532,726
Jackson	65,317,500	67,576,257	64,300,000	60,050,000	55,950,000
Morristown*	11,318,958	11,467,043	10,976,215	11,624,874	11,403,157
Pulaski	3,643,676	3,459,436	3,229,136	2,989,624	2,831,759
Tullahoma*	17,946,296	17,232,833	16,503,783	15,767,002	14,875,561
TOTAL	$ 202,083,316	$ 205,063,711	$ 199,889,939	$ 175,438,691	$ 158,647,388

*Utility's electric division owns at least some fiber-optic assets used by the broadband division to provide internet service. Debt for asset is carried on books of electric division for accounting purposes and is not included in table 7.

Source: Annual audits filed with Tennessee Comptroller of the Treasury and telephone interviews.

[326] Davidson and Santorelli 2014.

Table 8. Number of Customers of Municipal Broadband Providers in Tennessee Fiscal Years 2011-12 through 2014-15

	2011-12	2012-13	2013-14	2014-15
Bristol	13,799	14,450	14,853	15,925
Chattanooga	40,700	52,200	62,600	72,600
Clarksville	14,153	14,855	17,643	18,203
Columbia	4,867	5,026	5,245	5,555
Erwin	NA	NA	NA	157
Fayetteville	3,393	3,387	3,478	3,581
Jackson	15,799	15,965	15,163	14,728
Morristown	10,796	11,061	11,097	11,714
Pulaski	1,788	1,927	2,073	2,192
Tullahoma	2,852	3,016	3,247	3,379
TOTAL	108,147	121,887	135,399	148,034

Source: Telephone interviews and annual audits filed with Tennessee Comptroller of the Treasury.

Table 9. Municipal Broadband Providers in Tennessee: Annual Increase (Decrease) in Net Position of Broadband Division Fiscal Years 2011-12 through 2014-15

	2011-12	2012-13	2013-14	2014-15
Bristol	$ 1,790,221	$ 2,273,358	$ 2,723,358	$ 1,897,811
Chattanooga	3,936,000	5,550,000	11,407,000	11,676,000
Clarksville	(1,342,336)	(1,321,059)	(1,344,947)	1,971,225
Columbia	289,358	256,854	363,213	851,409
Erwin	NA	NA	NA	NA
Fayetteville	474,411	557,677	509,809	420,170
Jackson	4,463,780	5,538,681	3,127,307	4,527,690
Morristown	78,679	249,284	1,031,195	1,336,850
Pulaski	66,994	166,748	274,232	226,844
Tullahoma	(524,701)	(234,017)	218,424	332,948
TOTAL	$ 9,232,406	$ 13,037,526	$ 18,309,591	$ 23,240,947

Source: Annual audits filed with Tennessee Comptroller of the Treasury.

Electric Cooperatives

Electric cooperatives are private, non-profit corporations that provide retail electric service in many communities in Tennessee and across the nation. They have experience financing, building, and maintaining wired infrastructure connecting all the homes and businesses in their service areas. But electric cooperatives are not currently authorized to provide retail broadband service individually under Tennessee law.

Electric cooperatives have helped expand broadband access in rural areas in other states—including Alabama, Arkansas, Colorado, Georgia, Indiana, Michigan, Missouri, New Mexico, North Carolina, Oklahoma, Oregon, and Virginia—by building their own networks and serving as retail

internet service providers.[327] Like municipal providers and other private providers, many electric cooperatives have taken advantage of federal grants to help build their networks. For example, Northeast Oklahoma Electric Cooperative was awarded approximately $4.3 million in federal grants from the FCC's Rural Broadband Experiments program in June 2016 to connect approximately 3,000 homes and businesses in four rural counties in Oklahoma. The cooperative also received an $89 million loan from the US Department of Agriculture's (USDA) Rural Utilities Service Electric Loan program to expand broadband coverage in its service area. So far, it has connected 3,000 of its 6,000 electric subscribers and expects to complete the project in 2017.[328] North Alabama Electric Cooperative received a $19.1 million federal grant in 2010 through the USDA's Rural Utilities Service that it used to provide broadband to its members,[329] and a partnership between two electric cooperatives—Habersham Electric Membership Cooperative and Blue Ridge Mountain Electric Membership Cooperative—used a $33.5 million grant from the US Department of Commerce, National Telecommunications and Information Administration to provide broadband to members in Georgia and North Carolina.[330]

Other electric cooperatives are either building or planning to build broadband networks without federal grants. Co-Mo Electric Cooperative in Missouri is in the process of building a fiber-to-the-home network capable of serving all of its 32,000 electric customers. After failing to receive any federal grants for its project, the cooperative decided to start with a smaller pilot program for only 1,100 of its members. Subscribers in the program were asked to pay $100 sign-up fees before construction even started, though a local bank offered to pay the fee for any of its customers who signed up for service. The pilot program was a success with an estimated 46% of households subscribing to service and construction costs 15% below projections. Co-Mo is now expanding coverage in four phases, beginning with the most densely populated parts of its service area and, within these communities, prioritizing those with the highest demand. The cooperative was able to buy out its remaining debt with the USDA's Rural Utilities Service and is financing construction of its network with loans from the National Rural Utilities Cooperative Finance Corporation—a non-profit financing cooperative created in 1969 to raise funds for electric cooperatives—and local banks.[331] In Arkansas, Ouachita Electric Cooperative is partnering with South Arkansas Telephone Company to bring fiber-to-the-home service to all 9,500 of the cooperative's members.

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[327] North Alabama Electric Cooperative 2015; Zager 2013; Cash 2016a; Cash 2016b; Cash 2015a; Cash 2015b; and Kang 2016.
[328] Cash 2016a; and Kang 2016.
[329] Petersen "North Alabama Cooperative"; and ProPublica 2015.
[330] North Georgia Network 2016.
[331] Cash 2015a; Zager 2013; and National Rural Utilities Cooperative Finance Corporation "Our History."

Like Co-Mo, Ouachita plans to borrow from the National Rural Utilities Cooperative Finance Corporation to finance construction of its network.[332]

Tennessee already authorizes telephone cooperatives to provide broadband service.[333] Similar to electric cooperatives, telephone cooperatives are private, non-profit corporations, though they were created specifically to provide telephone service in rural areas of the state. All of Tennessee's telephone cooperatives provide broadband in their service areas, and several have benefited from the same grant programs as electric cooperatives in other states to upgrade their existing networks and expand broadband coverage.[334] Highland Telephone Cooperative, for example, was able to leverage $67 million in federal funding through a combination of grants and loans to build out fiber infrastructure for improving broadband service in Scott and Morgan counties in Tennessee and McCreary County, Kentucky.[335] According to statements attributed to Highland's Chief Executive Officer and General Manager by the *Tennessean*,

> with the fiber access, ranging from 15 to 1,000 megabits-per-second, schools can offer distance learning, businesses can easily connect with customers, and students can take courses online. The closest interstate is 20 miles away, making reliable connection that much more important to an area seeking to lure or develop business activity.[336]

While Tennessee's telephone cooperatives have helped expand broadband access in rural areas, their service territories do not extend as far as those of the state's electric cooperatives.

Electric cooperatives in Tennessee, like municipal electric systems, are prohibited from using electric ratepayer revenue to subsidize other services under the wholesale power contracts they sign with TVA, according to both TVA and the Tennessee Electric Cooperative Association. They are also required to conduct annual audits using Generally Accepted Accounting Principles; TVA reviews these audits every year.[337] Unlike those of municipal electric systems, electric cooperatives' audits are subject to review by the Tennessee Comptroller of the Treasury only when

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[332] Cash 2016b.
[333] Tennessee Code Annotated, Section 65-29-101 et seq.
[334] ProPublica 2015.
[335] McGee 2017.
[336] Ibid.
[337] Email from Cameron Heck, senior program manager, regulatory assurance, Tennessee Valley Authority, December 1, 2016; and email from Mike Knotts, vice president of government affairs, Tennessee Electric Cooperative Association, November 18, 2016.

a cooperative has received funding from or through the state. This has occurred, for example, when a cooperative has received money from the Tennessee Emergency Management Agency related to storm damage.[338] Similar to telephone cooperatives, electric cooperatives pay property taxes but are exempt from franchise and excise taxes as well as sales taxes on equipment purchases.[339] Like all providers, they would not pay privilege taxes or sales taxes on internet service.[340]

Partnerships

Municipalities—regardless of whether they have electric systems—and electric cooperatives as well as telephone cooperatives and counties are authorized to provide broadband in unserved areas through joint ventures under Tennessee Code Annotated, Section 7-59-316. These joint ventures must include at least one third party. Municipal electric systems and electric cooperatives that participate in them are prohibited under state law from using electric ratepayer revenue to subsidize broadband service and, as noted above, are subject to similar prohibitions in their wholesale power contracts with TVA.

These joint ventures are only authorized to provide service in areas that as determined by the Tennessee Regulatory Authority (TRA) lack access to broadband, have been developed for residential use for at least five years, lie outside the service area of a company that holds a local or state issued cable television franchise, and which no other provider intends to serve.[341] No joint ventures have been established for providing broadband under Tennessee Code Annotated, Section 7-59-316, according to TRA staff.[342]

Many private providers and some municipal providers in Tennessee employ staff and own and operate facilities and equipment that could be used to assist other entities in providing broadband. Providers can contract with each other to, among other things, collocate equipment in shared facilities, transmit data point-to-point for backhaul, connect providers' local networks to middle-mile and backbone networks for access to the wider internet, and provide network management and operations. These wholesale arrangements include many of the services that form the

[338] Email from Jean Suh, contract audit review manager, division of local audit, Tennessee Comptroller of the Treasury, December 19, 2016.
[339] Tennessee Code Annotated, Section 65-25-122; Tennessee Code Annotated, Section 65-29-129; and Tennessee Code Annotated, Section 67-6-325.
[340] US Public Law 114-125, Section 922; and interview with Barbara Sampson, assistant commissioner, Tennessee Department of Revenue, and Sherry Hathaway, tax policy and development manager, Tennessee Department of Revenue, April 7, 2016.
[341] Tennessee Code Annotated, Section 7-59-316.
[342] Email from John Hutton, telecom consultant, Tennessee Regulatory Authority, November 22, 2016.

components of providing retail broadband service to end users, and they are widely available.[343]

Municipal electric systems may need additional authorization to fulfill contracts for the component services involved in providing broadband to the extent that selling these services to electric cooperatives or other providers involves equipment, facilities, or on-site work outside municipal electric systems' service areas. Representatives for municipal providers say they are authorized to operate or lease equipment and facilities located within their electric service areas and to provide other support services under Tennessee Code Annotated, Section 7-52-601, to assist other entities that provide broadband outside their electric service areas.[344] At least one municipal electric system is reportedly doing so.[345] Further, while municipal electric systems are authorized to provide telecommunications services outside their electric service areas under Tennessee Code Annotated, Section 7-52-401 et seq., internet service is not explicitly included in the definition of telecommunications in state law. According to a 2014 opinion of the Tennessee Attorney General on whether electric cooperatives are authorized to provide retail broadband through their current authorization to provide telecommunications services,

> [t]he term "telecommunications" does not inherently include Internet service. . . . Unless the term "telecommunications" is expressly defined to include Internet services, therefore, that term cannot be construed as including such services.[346]

Public-private partnerships with existing providers can offer local governments a more active role in expanding broadband coverage in their communities. They can balance control, risks, and revenues among public and private sector partners to help communities navigate competitive broadband marketplaces and reduce barriers to expanding coverage for providers.[347] For example, Westminster, Maryland, has created incentives for its private, for-profit partner to sign up and retain subscribers by requiring it to pay $6 for every address the city-owned network passes regardless of whether homeowners subscribe to service. Westminster also requires its partner to help cover quarterly revenue shortfalls under certain circumstances. While the city pays the first $50,000 of any shortfall, its

[343] Email from Jeff Van Dyke, vice president, government affairs, AT&T Tennessee, December 9, 2016; and interview with Ben Lovins, senior vice president, telecommunications division, Jackson Energy Authority, January 13, 2017.
[344] Email from Mark Smith, attorney, Miller and Martin, January 17, 2017.
[345] Associated Press 2015.
[346] Tennessee Office of the Attorney General 2014a.
[347] Davidson and Santorelli 2014; and Lucey and Mitchell 2016.

partner is contractually obligated to pay the next $100,000.[348] According to New York Law School professors Charles Davidson and Michael Santorelli,

> public-private partnerships (PPP) can effectively address any aspect of the broadband connectivity paradigm . . . . Such partnerships are critical because they seek to "apply the resources of the private sector in meeting the needs of the public." These partnerships have been used in an array of contexts over the last few decades, including efforts to enhance public transportation and infrastructure, education, and public safety. More recently, they have become a popular means of "break[ing] the log jam" in an effort to achieve public sector goals during a period of shifting budget priorities. The use of PPPs recognizes that working to improve the supply of broadband is not an all-or-nothing proposition that pits the public sector against the private sector. Rather, there is a broad range of possibilities for engagement between stakeholders throughout this space.
>
> Structurally, PPPs vary widely, but many are forged to spread a project's risks. The amount of risk assumed by the public and by private parties differs depending on a number of variables, the most significant of which is the amount of capital invested. As an incentive for private firms to enter into PPPs and contribute resources at a high level, public entities typically reward private investment with a more tangible ownership stake and control over how the project will be realized. These interests are calibrated via contracts that delineate the scope of rights and duties for public and private partners. In the broadband context, there are numerous ways to structure PPPs to address issues on both the supply side and demand side. Properly implemented, these partnerships prove to be especially effective in achieving core public policy goals, including spurring new network build-out to previously unserved areas and promoting more robust broadband use in under-adopting communities, two core goals of broadband public policy.[349]

[348] Lucey and Mitchell 2016.
[349] Davidson and Santorelli 2014.

Partnerships, however, are not without risk.[350] As noted above, Provo, Utah, and Memphis—Memphis Networx—developed broadband networks in partnership with private, for-profit entities. Memphis had difficulty attracting retail providers to use its wholesale network, while Provo's retail partner could not generate enough revenue to cover the city's debt payments. Both eventually sold their networks at a loss.[351] A public-private partnership in Monticello, Minnesota, also failed because it could not compete with an incumbent provider that was able to reduce rates below the cost of providing service.[352]

Coordinating the efforts of state and local governments and the private sector can help address gaps in broadband adoption and coverage.

Local planning and coordination with and among existing state agencies will be essential for increasing both adoption and access in Tennessee. Local governments are best situated to determine their communities' needs, especially for adoption programs. Much of this planning and coordination could take place within existing collaborative organizations, including the state's development districts and the Joint Economic and Community Development Boards authorized under Public Chapter 1101. Connected Tennessee—the state's affiliate of the non-profit Connected Nation that collected information on broadband availability, adoption, and use—also provided assistance to communities in developing local adoption and access plans before its funding ran out. Community plans can determine target populations for adoption programs and the most appropriate strategies for expanding coverage.[353]

Several states have created separate broadband offices to coordinate access and adoption strategies. According to a study by Strategic Networks Group, one of the consultants that produced ECD's broadband survey, states with broadband offices have higher rates of access, adoption, and use.[354] While this approach can enable better coordination, it can create duplication, add complexity to decision making, and add to the cost of governing. SNG found the average annual budget for broadband offices in other states, not including California and New York, was almost $600,000. California's annual budget for its broadband office is $330 million and New York's is $500 million.[355]

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[350] Davidson and Santorelli 2014; and Lucey and Mitchell 2016.
[351] Telephone interview with Dana Jeanes, chief financial officer, Memphis Light Gas and Water, November 20, 2015; Davis 2007; and Davidson and Santorelli 2014.
[352] Mitchell and Gonzalez 2014.
[353] Clarksville-Montgomery County Technology Planning Team and Connected Tennessee 2015.
[354] Strategic Networks Group 2016.
[355] Ibid.

Fortunately, this type of strategic coordination can be accomplished without having to create any new state agencies or offices. An example can be found with the state's Basic Education Program Review Committee, which meets periodically to help the administration and legislature set education funding priorities.

The state also has existing resources to track broadband infrastructure needs, including its annual infrastructure survey. The survey, which already reports needs for the next five years for other utilities, "provides the basic information that helps state and local officials match needs with funding."[356] It "has become a tool for setting priorities and making informed decisions," and "for most officials in rural areas and in smaller cities, [it] is the closest thing they have to a capital improvements program."[357]

[356] TACIR 2016.
[357] Ibid.

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Glossary

Adoption: The process of integration of the internet in general, and broadband in particular, by individuals (in contrast to organizations or industrial sectors) to their everyday lives.

Affordability Gap: The difference between the costs to consumers to have broadband services compared to their ability to pay for it.

Analog: Data that is represented in a physical, non-digital way such as magnetic tape or vinyl records.

Backbone: One of the principal data routes between large, strategically interconnected networks and core routers on the internet. An internet backbone is a very high-speed data transmission line that provides networking facilities to relatively small but high-speed internet service providers all around the world. Backbone networks are primarily owned by commercial, educational, government and military entities because they provide a consistent way for internet service providers to keep and maintain online information in a secure manner.

Backhaul: The telecommunications link used to transport traffic from a geographically distant point, such as a wireless base station, to a significant aggregation point in the network, such as a mobile telephone switching office or internet peering point.

Bandwidth: The amount of data that can be sent through a network or modem connection. It is usually measured in bits per second (bps).

Bit (binary digit): The smallest unit of information in a computer. It is used for storing information and has a value of true/false or on/off. An individual bit has a value of either 0 or 1, which is generally used to store data and implement instructions in groups of bytes. A computer is often classified by the number of bits it can process at one time or by the number of bits in a memory address.

Broadband: High-speed internet service that enables users to originate and receive high-quality voice, data, graphics, and video.

Byte: A storage unit capable of representing a single character, such as a letter, number or symbol. In most computers, one byte is equated to eight smaller units called bits.

Cable Modem Service: Internet service delivered by cable television companies through the same coaxial cables that deliver sound and pictures to television sets.

Capacity: The amount of data measured in binary units called bits that users can send or receive per second.

Census Block: Statistical areas bounded by visible features such as roads, streams, and railroad tracks and by nonvisible boundaries such as property lines, city, township, school district, county limits and short line-of-sight extensions of roads. Census blocks are the smallest geographic unit for which the US Census Bureau collects and tabulates decennial census data.

Census Tract: A small, relatively permanent statistical subdivision of a county, designed to contain roughly 1,000 to 8,000 people who are relatively homogeneous with respect to their demographics, economic status and living conditions.

Code Division Multiple Access (CDMA): A digital cellular network standard that does not constrict bandwidth's digital signals or frequencies but spreads them over a fully-available spectrum or across multiple channels via division, resulting in improved voice and data communication capability and a more secure and private line. The CDMA digital standard is a leading communications network standard in North America and parts of Asia.

Coaxial Cable: A type of shielded and insulated copper cable that is used in computer networks and to deliver cable TV services to end users. It was first commercially implemented in the early 1940s and is used for both baseband and broadband data communication services.

Common Carrier: A telecommunications provider, such a telephone company, that offers its services for a fee to the public indiscriminately.

Community Anchor Institutions: Schools, libraries, medical and healthcare providers, public safety entities, institutes of higher education and other community support organizations that provide outreach, access, equipment and support services to facilitate greater use of broadband service by the entire population and local governments.

Competitive Local Exchange Carrier (CLEC): A telephone company competing with established local telephone businesses by providing their own network and switching. CLECs arose as a result of the Telecommunication Act of 1996, which was intended to promote competition among long distance and local phone service providers. The term is used to differentiate between new or potential competitors and established local exchange carriers.

Connect America Fund: An initiative of the Federal Communications Commission to bring broadband to unserved areas through subsidies to incumbent internet service providers.

Connected Nation: A national not-for-profit organization committed to expansion of broadband through improvement of digital literacy, research and analysis, policy consultation, and mapping.

Cooperative: A private non-profit membership corporation owned and controlled by those who use its services.

Dark Fiber: Unused optical fiber that has been laid but is not currently being used in fiber-optic communications. Because fiber-optic cable transmits information in the form of light pulses, a "dark" cable refers to one through which light pulses are not being transmitted.

Data Caps: Limits placed on downloading and uploading of data per household or user. Exceeding the caps could subject users to penalties such as additional charges, reduction of access speed, suspension of service, or even termination of service.

Data Over Cable Service Interface Specification (DOCSIS): An internationally recognized standard allowing high speed data transfer on existing cable TV systems (CATVSs) used by many cable operators to provide internet access to their customers through a cable modem. The latest version of the standard also supports high definition televisions (HDTVs).

Digital Data: Data that represents other forms of data using specific machine language systems that can be interpreted by various technologies. The most fundamental of these systems is a binary system, which simply

stores complex audio, video or text information in a series of binary characters, traditionally ones and zeroes, or "on" and "off" values.

Digital Divide: The gap that exists between people that have access to broadband and know how to use the internet and those who do not have such access or knowledge.

Digital Subscriber Line (DSL): Service delivered by local telephone companies over upgraded copper-wire telephone networks that were originally built to provide traditional wireline voice service.

Distance Learning: Education that uses one or more specified technologies (e.g. internet or audio conferencing) to deliver instruction to students who are separated from the instructor and to support regular and substantive interaction between the students and the instructor.

Download: The process of receiving data from the internet.

E-Rate Program: A federal Universal Service Fund program that provides discounts on telecommunications and information services to eligible schools and libraries.

Facilities-based Competition: Competition between providers of the same or similar services, but where the service is delivered by different or proprietary means or networks.

Fiber-optic cable: A wired technology that converts electrical signals carrying data into light and sends the light through transparent glass fibers about the diameter of a human hair. Telephone companies provide most fiber-optic broadband service.

Fiber-to-the Premises/Fiber to the Home: High speed internet infrastructure that connects directly to residents' homes. By comparison, some communities have fiber infrastructure that connects business districts or community anchor institutions like schools and hospitals.

Fixed Wireless Access: A type of wireless broadband data communication, which is performed between two fixed locations, connected through fixed wireless access devices and equipment.

Global System for Mobile Communications (GSM): A type of second generation mobile telephone technology that uses digital signaling and speech channels. It has the ability to roam and switch carriers.

Gigabit: A data measurement unit applied to digital data transfer rates (DTR) and download speeds. One Gb equals one billion bits or one thousand megabits.

Healthcare Connect Fund: A program of the FCC that subsidizes the cost of broadband infrastructure and service for public and non-profit health care providers in rural areas.

Hotspot: A specific location or device that provides internet access via a wireless local area network (WLAN). Some are free, but most require a password for access.

Hybrid Fiber Coaxial Facility: A broadband telecommunications network that combines optical fiber and coaxial cable.

Household: All the people who occupy a housing unit (such as a house or apartment) as their usual place of residence, including related family members and all unrelated people, if any, such as lodgers, foster children, wards, or employees who share the housing unit. A person living alone in a housing unit, or a group of

unrelated people sharing a housing unit such as partners or roomers, is also counted as a household. The count of households excludes group quarters.

Housing Unit: A house, an apartment, a mobile home or trailer, a group of rooms, or a single room occupied as separate living quarters, or if vacant, intended for occupancy as separate living quarters. Separate living quarters are those in which the occupants live separately from any other individuals in the building and which have direct access from outside the building or through a common hall. For vacant units, the criteria of separateness and direct access are applied to the intended occupants whenever possible.

Incumbent Local Exchange Carriers (ILECs): Any US telephone organization that was providing local service at the time the US Telecommunications Act was enacted in 1996. These organizations opened regulatory barriers to entry in the telecommunications field. ILECs included GTE Corp. and the former Bell companies (known as the "Baby Bells"), which were formed when the American Telephone Telegraph Company (now ATT) was broken up in 1983.

Internet of Things: The concept of connecting any device with an on and off switch to the internet and/or to each other including devices such as cellphones, coffee makers, washing machines, headphones, lamps, wearable devices, traffic lights, street lights, etc.

Internet Service Provider (ISP): A company that provides customers with internet access. Data may be transmitted using several technologies, including dial-up, DSL, cable modem, wireless or dedicated high-speed interconnects.

Last Mile: Connection to end users–businesses and residential locations.

Latency: The lag time between when a signal is sent and when it is received.

Licensed Spectrum: Allows for exclusive, and in some cases non-exclusive, use of particular frequencies or channels in particular locations.

Lifeline Program: A program of the Federal Communications Commission supported by proceeds from the Universal Service Fund through which eligible participants receive a discount for telephone or internet service.

Long Term Evolution (LTE): A 4G wireless broadband technology that provides speeds up to 100 Mbps download and 30 Mbps upload.

Megabit (Mb): A data measurement unit applied to digital computer or media storage. One Mb equals one million (1,000,000) bits or 1,000 kilobits (Kb).

Megabits per second (Mbps): A measurement unit applied to digital data transfer rates (DTR) related to any type of media or computer. One megabit equals 1,000,000 bits.

Middle Mile: Provides a link from the internet backbone to the last-mile networks of local providers (such as cable or phone companies) that provide broadband service to end users.

Modem: A device or program that enables a computer to transmit data over, for example, telephone or cable lines. Computer information is stored digitally, whereas information transmitted over telephone lines is transmitted in the form of analog waves. A modem converts between these two forms.

Next Generation 911 (NG911): An emergency response system that integrates the core functionalities of the E911 System and also supports multimedia communications (such as texting, e-mail, and video) to the call center/dispatcher.

One touch make ready: Process in which a pole owner can designate a single contractor to move all attachments on a pole at the same time, rather than relying on multiple companies to each move their own cables.

Pole Attachment: Any attachment by a cable television system or other provider of telecommunications service to a pole, duct, conduit, or right-of-way owned or controlled by a utility.

Price Cap Carriers: Incumbent local exchange carriers that are regulated according to mathematical adjustments designed principally to reflect expected industry-wide increases in efficiency from technological and other innovations, as well as fluctuations in inflation and other macroeconomic variables. A price-cap approach rewards incumbents for efficiency over time.

Rate of Return Carriers: Incumbent local exchange carriers not subject to price cap regulation but which may charge retail rates sufficient in the aggregate to cover their anticipated expenses plus a reasonable return on net investment.

Satellite: A radio relay station that orbits the earth. A complete satellite communications system also includes earth stations that communicate with each other via the satellite. The satellite receives a signal transmitted by an originating earth station and retransmits that signal to the destination earth station(s). Satellites are used to transmit telephone, television and data signals originated by common carriers, broadcasters and distributors of cable TV program material.

Smart Grid: The electric delivery network, from electrical generation to end-use customer, integrated with sensors, software, and two-way communications technologies to improve grid reliability, security, and efficiency.

Smart Meter: A digital meter (typically electric) located on the customer premises that records energy usage and has two-way communications capabilities with utility systems.

Speed: Broadband capacity, measured by the number of bits of data transferred per second, usually expressed in kilobits (1000 bits per second—Kbps), megabits (1,000,000 bits per second—Mbps), and gigabits (1,000,000,000 bits per second—Gbps); speed is also affected by latency.

Spectrum: The range of electromagnetic radio frequencies used in the transmission of sound, data, and television.

Store-and-forward-technologies: A method primarily used in telecommunications networks, where remote subscribers lack direct or dedicated connections. It works by storing the message transmitted by the source device on an intermediary device, generally a server. The server then locates the destination device from it database of subscribers, initiates a connection and transmits the data packet that was originally sent by the source device.

Telemedicine: The remote diagnosis and treatment of patients by means of telecommunications technology.

Throughput: See "Capacity."

Universal Service Fund: A system of telecommunications subsidies and fees managed by the FCC intended to promote universal access to telecommunications services in the United States. The FCC expanded the program in 1997 in compliance with the Telecommunications Act of 1996 and provides subsidies through four basic programs that address affordability, rural health care, and schools and libraries support. Telecommunications companies are required to pay a percentage of their interstate end-user revenues to the Universal Service Fund.

Unlicensed Spectrum: Spectrum that users can operate without a Federal Communications Commission license but must use certified radio equipment and must comply with the technical requirements, including power limits.

Usage-Based Pricing (UPB): A practice allowing internet service providers to change the price to customers, or otherwise provide service adjustments, based on the volume of data used.

Upload: The process of copying files from a smaller peripheral device to a large central system. This process may involve transferring data from a local computer to a remote computer (and usually large) system, or transferring data from a computer to a bulletin board system.

Voice Over Internet Protocol (VoIP): A technology that allows voice calls using a broadband Internet connection instead of a regular (or analog) phone line.

Wi-Fi (wireless fidelity): A type of wireless network technology used for connecting to the Internet. Wi-Fi frequencies ensure no interference with cellphones, broadcast radio, TV antenna and two-way radios is encountered during transmission. Wi-Fi works very similarly to an AM/ FM radio but is a two-way communication channel. Wi-Fi works over longer distances than Bluetooth or infrared and is also a low power unobtrusive technology, making it suitable for portable devices such as laptops and palmtops.

Wireless Internet Service Providers (WISPs): A wireless internet service provider is an internet service provider that allows users to connect to a server through a wireless connection such as Wi-Fi. WISPs provide additional services such as virtual private networking VoIP and location-based content.

3G, 4G, 5G (3rd, 4th, 5th Generation): Standards made for mobile telecommunication which are maintained and described by the International Telecommunication Union.

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