Monterey Bay
ECONOMIC PARTNERSHIP
BROADBAND INITIATIVE

# STATE OF BROADBAND IN THE MONTEREY BAY REGION

*October 2023*


www.mbep.biz @MBEPartnership

# ACKNOWLEDGEMENTS

Monterey Bay Economic Partnership (MBEP) Broadband Initiative was established to advocate for reliable and affordable internet service - an essential utility—for the way we live, learn, and operate as a community. Advocacy for this critical utility is not possible without dedicated and passionate staff working in partnership with community advocates, academia, business leaders, internet service providers, and policymakers to fulfill our mission of improving the economic health and quality of life in our tri-county region. Thank you to the many member cities, counties, and digital equity champions in our region, state, and nation who continue to work tirelessly to help develop economically thriving, resilient communities that include broadband for all across.

MBEP acknowledges and thanks the early trailblazers advocating for broadband access and infrastructure in our region like Rene Mendez and Larry Samuels. We thank the longstanding partnership with Central Coast Broadband Consortia (CCBC) members as well as leadership of the tri-county Board of Supervisors championing digital equity especially in hard to reach mountainous, rural and farming areas. Special thanks to Supervisor Chris Lopez, the founding members of South Salinas Valley Broadband Authority and countless others who have stood alongside MBEP from the very beginning to lift connectivity needs of our rural communities.

MBEP also extends gratitude to our funders and board members for their ongoing support and guidance. And it is always a team effort - Thank you to the following on the MBEP team:

- Ameer Othman, Director of Economic Development and Digital Equity
- David Witkowski, Senior Advisor on Broadband
- Doreen Danielson, former Senior Advisor on Broadband & Economic Development
- Jessica Gilden, Marketing & Communications Manager
- Alia Elyas, Research and Policy Associate
- Marie Vasari, Media & Communications Advisor

It is our hope that the State of Broadband in the Monterey Bay Region paper will encourage and inspire deployment of broadband to create Digital Equity throughout the Monterey Bay and greater Central Coast regions.

Tahra Goraya, MA, MPA
President & CEO

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

Monterey Bay is a beautifully diverse and vibrant region in both its geography and community facing unique digital challenges. This white paper addresses the current state of broadband and digital equity in the region and offers recommendations for improving infrastructure, access, and affordability from a "one size fits all" approach to one that is flexible and adaptable to the region. While the region enjoys varying levels of broadband infrastructure and connectivity, disparities in broadband access and consistency persist. Rural areas face significant challenges, resulting in a digital divide that hinders progress and inclusivity, and exacerbates economic and educational inequalities. Investing in broadband infrastructure, fostering public-private partnerships, and expanding last-mile connectivity are essential steps toward closing the Digital Divide.

Monterey Bay Economic Partnership (MBEP) created the Broadband and Digital Equity Initiative to champion reliable, accessible, and affordable internet service in Santa Cruz, San Benito, and Monterey Counties. MBEP was an early advocate for classifying broadband as an essential utility for how we live, learn, and operate as a community. The global pandemic further highlighted the deep digital divide in our rural and underserved counties - remote work, telehealth, small business operations, and education. As a result, MBEP partnered with the Central Coast Broadband Consortium (CCBC), and serves as executive director for the South Salinas Valley Broadband Authority (SSVBA) to convene multi-sector stakeholders toward collective impact in programs and policies that address the region's digital divide.

MBEP's definition of the Digital Divide pertains to the gap between those of a populace with accessible, affordable, and reliable internet connectivity and the digital literacy, skills, and support needed to engage online effectively and those of the underserved and unserved populace with no access. The overall approach to bridge those digital inequities and unequal levels of access requires holistic yet timely action from leading regional stakeholders across the three counties. To do so, it is crucial to address the region's infrastructure, awareness, and access strategic needs by:

- Emphasizing the need for designating priority locations that need infrastructure advancements.
- Increasing awareness through advocacy, education, and engagement.
- Promoting adoption by supporting policies and grant guidelines that increase affordability and service in rural communities within the Monterey Bay region.

Local and regional governments long-term initiatives must develop alongside short-term efforts that include outreach for Affordable Connectivity Program (ACP) enrollment at community anchor institutions and connecting residents to nonprofits and other local entities providing digital literacy and skills training. These strategic plans should focus on developing partnerships and collaborations with regional private service providers to produce equitable, community-oriented, financially viable infrastructure projects to spur economic and workforce development in its surrounding communities.

When considering broadband infrastructure, we encourage flexible and adaptable technology strategies to create approaches and models that will connect unserved and underserved communities in the geographically diverse Monterey Bay regions. A "one size fits all" approach to technology is not helpful and is unlikely to meet the goal of broadband for all. MBEP recommends the following technology three strategies:

## Fixed Wireless Technology

- Local governments and Internet Service Providers (ISPs) should collaborate to equitably invest in wireless broadband infrastructure in areas where deploying fiber is too costly, especially in unserved and underserved regions.
- Community education and outreach are essential to ensure that rural residents and businesses recognize the benefits of wireless broadband, fostering the technology's adoption.
- County and municipal governments need to devise strategies and policies to maintain wireless broadband affordability in rural areas, particularly for communities with service constraints due to geography or topography.
- County and municipal governments should also stay updated on the latest fixed wireless technology advancements that can address current security and reliability issues, which have previously deterred investment in wireless broadband.

## Fiber-Optic Technology

- Establish public-private partnerships for equitable fiber broadband expansion.
- Collaboration between county and municipal governments with local ISPs and telecom companies has successfully addressed the high costs of funding fiber-optic infrastructure projects.
- Policymakers should think about regulatory adjustments to simplify permitting and licensing processes, eliminating barriers that increase costs and delay the deployment of fiber optic technology.
- Form a public-private partnership to collaborate with the regional broadband consortium and broadband JPA, ensuring equitable fiber broadband infrastructure expansion in rural areas. This could involve partnering with local ISPs and telecom companies to offset the substantial costs of constructing fiber-optic cables in such regions.

## Hybrid Broadband Model

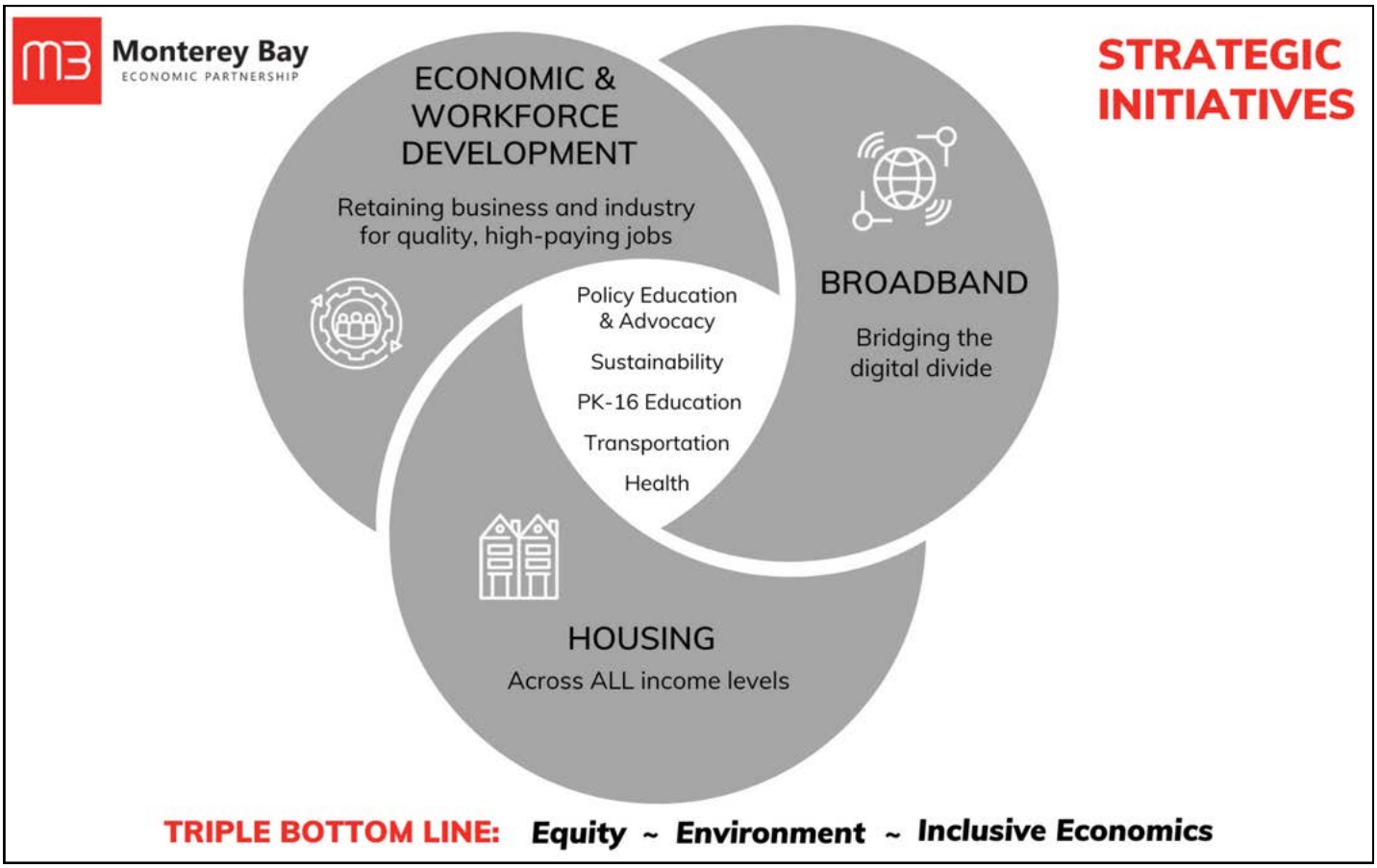
The Hybrid Model proposal combines the two broadband technologies, ensuring that ISPs would not refuse to provide broadband services to locations that cannot utilize fiber technology and would be required to offer wireless technology instead. The Hybrid Broadband Model proposal holds local governments, the regional broadband consortium, and the ISPs accountable for providing one of the two technologies to unserved and underserved areas, ensuring that residential and commercial community members can equitably participate in all aspects of their local economy.

## Conclusion

Access to broadband internet has become a critical necessity impacting education, healthcare, and economic opportunities. Bridging the digital divide in the Monterey Bay Region is an urgent call to action. This white paper underscores the importance of equitable digital access. It outlines a foundational roadmap to develop a broader understanding of the role that broadband occupies in the region today and vital considerations on how to best develop a strategic plan for equitable access for all and a more inclusive and digitally connected future. Our collective responsibility is to ensure that every resident can benefit from the opportunities of the digital age.

## About the Monterey Bay Economic Partnership

The Monterey Bay Economic Partnership (MBEP) is a regional, member-supported nonprofit organization consisting of public, private and civic entities located throughout the counties of Monterey, San Benito and Santa Cruz. MBEP's vision is to create a thriving region with quality jobs, excellent education and health care, housing for all, and broadband access while preserving the natural beauty of our environment. MBEP accomplishes this work through our initiatives: Housing; Broadband; Economic and Workforce Development; and Policy Education and Advocacy. MBEP is a trusted nonpartisan organization with a track record of working for the triple bottom line: equity, environment, and inclusive economic growth. Each initiative incorporates intentional intersection of field research as well as business and community perspective while considering sustainability, transportation, education and public health. The result is a holistic approach to economic prosperity in the tri-county region.



# BACKGROUND:
# MBEP DIGITAL EQUITY EFFORTS


Monterey Bay Economic Partnership (MBEP) is a regional member-supported nonprofit organization of public, private, and civic entities throughout Monterey, San Benito, and Santa Cruz counties. Founded in 2015, MBEP's mission is to improve the region's economic health and quality of life. MBEP currently serves as co-convener and lead project manager on several initiatives impacting Monterey, San Benito, and Santa Cruz counties directly tied to building economic resilience in rural communities and reducing the Digital Divide in historically disinvested communities. The following list exemplifies the unique value of MBEP serving to lead and write the strategic plans:

- MBEP has successfully led, directed, and managed the Central Coast Broadband Consortium (CCBC) by securing California Public Utilities Commission (CPUC) funds and functioning as the day-to-day administrator of the consortium.
- MBEP successfully helped form and now serves as the Executive Director of a broadband Joint Powers Authority (JPA) in rural South Monterey County known as South Salinas Valley Broadband Authority (SSVBA).
- MBEP has led the Regions Rise Together inclusive economic development initiative funded by the James Irvine Foundation.
- MBEP, as a Uplift Central Coast Coalition co-founder, is a regional six-county co-convener for the Community Economic Resilience Fund (CERF) for inclusive economic development that includes Monterey, Santa Cruz, and San Benito counties.

MBEP's role as a Digital Equity advocate and leader is critical to the region to ensure high-speed connectivity evolves from a benefit for those who can afford it to a necessary service for all. MBEP has routinely demonstrated its experience and successes in assisting regional stakeholders and groups to expand and achieve equitable broadband deployment in the region. Critical to MBEP's success in building regional, collaborative broadband-related efforts is centralizing the concept of Digital Equity in planning and deployment to ensure the community's digital needs are addressed and ultimately advance the region's economic health and resilience.

Attaining broadband equity in the region requires an emphasis on infrastructure, access, and awareness as the primary strategic prongs, all of which would be essential to address the visible Digital Divide. As it pertains to rural communities, they experience unique challenges that have historically resulted in lower rates in broadband internet connection at home. Some of these challenges are related to limited infrastructure, lack of industry diversity, and limited access to telehealth and distance learning. In order to address specific regional broadband needs, it is also crucial to understand differences among various broadband technologies that would align with the Monterey Bay region's Digital Equity needs.

# BROADBAND FOR ALL


Legislative and policy action was fast-tracked due to the increased pressures caused by the COVID-19 pandemic which revealed a pre-existing and growing truth that broadband is now a required utility in daily life. In response to these aforementioned pressures and tremendous needs, Governor Gavin Newsom signed the historic broadband legislation, Senate Bill 156, into law in July 2021. The legislation provided a once-in-a-lifetime investment to expand broadband infrastructure and access throughout the state. The signed legislation targeted the state's Digital Divide by funding broadband programs that initiate and support middle-mile and last-mile broadband infrastructure especially critical in connecting California's most chronically unserved and underserved communities.

SB 156 is one of the country's most significant state broadband investments aimed at accelerating California's commitment to bridging the digital divide by increasing equitable, affordable access to high-speed internet service across California (Public Policy Institute of California, 2023). With $6 billion allocated towards expanding broadband infrastructure, the overall goal of SB 156 is to ensure equitable access in the deployment of high-speed broadband to unserved and underserved communities. According to the California Telehealth Policy Coalition, middle-mile networks are primarily owned by private internet service providers (ISPs) that have, to date, not built out sufficient service to rural areas with low population density or too-low-income areas (CCPHA, 2021). The state of California is to initiate, develop, and complete broadband programs with the following criteria to connect residents and businesses to high-speed broadband:

- **Open Access Middle-Mile Network:** As specified in SB 156, the California Department of Technology (CDT) and its Office of Broadband and Digital Literacy oversee the state's Middle-Mile Broadband Initiative (MMBI). The state of California is in the process of acquiring, building, maintaining, and operating a virtual open-access statewide middle-mile network. Middle-mile broadband refers to the physical infrastructure connecting local networks, such as homes and businesses, to the more extensive internet backbone. It plays a crucial role in ensuring that internet traffic is efficiently transmitted between local

networks and the rest of the world. It is the intermediate stage between the local last-mile network that reaches individual homes and businesses and the long-haul network that spans vast distances between cities and countries. As defined as an "open-access" network, providers and entities have wholesale access to broadband infrastructure, allowing any networks to connect on equal economic and service terms. The middle-mile network typically covers a geographic area of several miles and provides high-speed connectivity for data to travel between local networks and the wider internet. Private telecommunication companies often own and operate middle-mile networks and their associated infrastructure. Still, they have not built sufficient capacities to feasibly reach high-cost rural areas with either low-population density or largely low-income communities. ***California's leading effort in developing its middle-mile infrastructure is to create a statewide open-access middle-mile network meant to give service providers the needed infrastructure to leverage and expand their service to connect unserved and underserved communities throughout the state.***

- **Last-Mile:** In addition to the middle-mile network, the SB 156 Broadband Infrastructure Package includes amendments to the rules for the Broadband Infrastructure Grant Account program within the California Advanced Services Fund (CASF) and allocates $2 billion to the account to fund last-mile projects. Last-mile broadband refers to the final segment of a telecommunications network that connects and physically reaches individual homes, businesses, or other end-users to the broader internet. It is often considered the most critical and challenging part of the network because it involves the physical infrastructure needed to connect customers to the internet, which most often in the U.S. includes cable, DSL, or fiber-optic and their associated equipment. Last-mile broadband is the crucial link that connects homes, schools, hospitals, and businesses to the global digital infrastructure, providing access to the internet and enabling communication, information sharing, and access to digital services. As the final and most costly part of the network to deploy, the state's injection of funds in last-mile projects allows for expanded capabilities to extend such deployment and potentially aid in lowering the costs that would have trickled down to the consumers in the local communities to subscribe to the newly-developed network.

# REGIONAL DIGITAL DIVIDE

Digital Divide reinforces and expands disparities in critical programs and access to essential services. To ensure that the Digital Divide in the Monterey Bay region is adequately addressed, there is a need to define the loosely understood concept of the "Digital Divide" to better synthesize the extent of its impact. MBEP's conception of the Digital Divide considers its regional context to define the term and later form the organization's multi-layered approach to addressing Digital Equity concerns across the three counties of Monterey, San Benito, and Santa Cruz.

## Digital Divide: A Definition

The term "Digital Divide" holds varying meanings depending on the entity or stakeholder in question. As highlighted by the Congressional Research Service in 2021, it broadly denotes the chasm between individuals with access to telecommunications, information technologies, and high-speed broadband, versus those without. The MBEP initiative refines this understanding, drawing from the National Digital Inclusion Alliance (NDIA)—a collective of digital inclusion experts—and Harvard's Imagining a Digital Economy for All (IDEA) 2030 initiative. These resources helped craft a comprehensive perspective of the Digital Divide, encapsulating the myriad causes of broadband access disparities, strategic organizational responses, and the specific context of the Monterey Bay region. For MBEP, the Digital Divide signifies the disparity between individuals who enjoy reliable internet access, digital literacy, and the necessary skills for effective online engagement, and those marginalized due to lack of access. With technology's rapid evolution threatening to exacerbate this divide, it's imperative to deconstruct its components and pinpoint the reasons behind the evident gaps in the Central Coast.

## The Varying Degrees of Broadband Access

Many areas in Monterey, San Benito, and Santa Cruz counties have broadband access. However, only some of these areas fully subscribe to reliable, high-speed broadband. Various reasons contribute to this uneven access, which includes the following:

- Lack of Infrastructure seen in areas with limited terrestrial broadband coverage and insufficient internet speeds available.
- Lack of, or insufficient, Internet Service Provider (ISP) competition in areas, which leads to higher prices for monthly subscriptions for consumers to access the internet.
- Upselling by ISPs for packages or bundles that cause cost-prohibitive pricing that produce inequity in access across income groups and limit broadband speeds beyond their actual availability.
- Lack of awareness about federal subsidies for more affordable services that target low-income households and groups most in need of assistance.
- A pandemic-compounded divide that further expanded the gaps in access and adoption for unserved and underserved communities in rural areas of the region.

- Inadequate digital proficiency and digital literacy training for residents and commercial entities in all three counties.

Currently, the Monterey Bay region's broadband access is severely impacted by limited, or lack thereof, necessary infrastructure. The extractive profit-seeking efforts of ISPs through restricted competition eventually lead to higher prices for consumers' monthly subscriptions and their upselling of packages or bundles that cause cost-prohibitive pricing. The region's broadband access is further affected by the general public's lack of awareness about federal subsidies for service, a sentiment exacerbated and seen highly by the pandemic-caused divide, especially in access and functional need communities, and inadequate digital literacy training for residents and commercial entities.

There is concern that as so many services – health, educational, commercial and governmental – become available online, groups without digital access will be left behind and unable to participate in similar opportunities in life and work. According to the 2021 U.S. Census Bureau report, the Hispanic and Latino population comprises an average of 62% of residents, mainly compressed in the tri-county region's low-income, underserved, rural areas. Monterey, San Benito, and Santa Cruz counties are home to low-income residents who rely on regular meal assistance, students whose performance or enrollment depends on a reliable internet connection, and small businesses unable to reach residents, expand their services, or survive. The latest Internet Use Survey by the National Telecommunications and Information Administration (NTIA) highlighted 54% of responses that stated they would purchase home internet if they could only afford it. However, for many households, the only affordable price is $0. The overall approach requires closing the Digital Divide and doing so as quickly as possible. Therefore, it is crucial to address the region's infrastructure, awareness, and access strategic needs by:

- Emphasizing the need for designating priority locations that need infrastructure advancements.
- Increasing awareness through advocacy, education, and engagement.
- Promoting adoption by supporting policies and grant guidelines that increase affordability and service in rural communities within the Monterey Bay region.

## *Infrastructure*

Broadband infrastructure, awareness, and access are interconnected elements that influence the availability and adoption of high-speed internet. This tri-pronged notion is essential for promoting equitable and inclusive access to high-speed broadband connection in rural communities in the Monterey Bay region. Broadband infrastructure refers to the physical networks that provide internet connectivity, such as fiber-optic cables, wireless networks, or satellite systems. The availability and quality of broadband infrastructure in a community directly affect the internet access and speeds residents and commercial entities can enjoy. While there is a competitive market for broadband access in most of California, private providers are incentivized to create the infrastructure necessary to sign up as many customers as is profitable to them. However, gaps in broadband adoption exist almost exclusively in California's rural areas and low-income communities. ***Rural regions of Monterey, San Benito, and Santa Cruz counties that need more broadband infrastructure or have outdated networks continue to struggle to provide adequate internet access, hindering economic development, education, healthcare, local governance, and social engagement.***

## Awareness

Awareness and education is critical to the success of digital inclusion efforts and is instrumental to bridging the Digital Divide. Outreach and community engagement ensures that available programs and resources reach the intended audiences that qualify for them; it enables communities' utilization of the public assistance offered. Awareness across communities, governments, and industries informs the value of investing in broadband infrastructure as a necessary means to economic advancement. High-speed broadband connection for improved quality of life, work, education, healthcare, and local governance unites consumers in understanding, organizing, and demanding a high-speed connection, recognizing its direct correlation to an ever-growing, advanced economy. When residents and small businesses understand the potential benefits of high-speed internet, they are more likely to support efforts to expand access and improve infrastructure for a more resilient economy.

Additionally, there are underutilized assistance programs such as Affordable Connectivity Program (ACP). As demonstrated through the ACP Enrollment Tracker in the table below, lack of awareness and education of these opportunities has led to a significant percentage in all three counties remaining unsubscribed. The unsubscribed shares per county are eligible individuals who have not taken advantage of the ACP's assistance.

**ACP Eligible Households and Enrollment % Across the Monterey Bay Region**

| | Eligible Households | Enrolled Households |
|---|---|---|
| **Monterey County** | 47% | 27% |
| **San Benito County** | 52% | 30% |
| **Santa Cruz County** | 42% | 25% |
| **State of California** | 45% | 43% |

*Data Collected August 2023*

With all three counties' enrollment rates falling well behind the state average, a more significant regional investment by county and municipal offices is required to support existing outreach programs, provide enrollment assistance in multiple languages to better reach historically disinvested Black, Indigenous, and people of color communities, and disperse communications across all platforms to encourage public attention. The region is collectively leaving behind an estimated $2.5 million in funding available for eligible households that have yet to enroll in the ACP program for various reasons, including a lack of outreach and awareness.

## Access

Access to broadband services is critical for individuals and communities to take advantage of community opportunities and participate in all aspects of daily life. With broadband access, community members can participate in online learning, remote work, and telemedicine. Lack of access can also contribute to the existing Digital Divide, where many in the Monterey Bay region cannot access the same opportunities and benefits as others. Broadband access in the following areas is a crucial step toward continued economic development:


- **Economic Growth:** Broadband access is a crucial driver of economic growth and job creation. Furthermore, research suggests broadband access is a strong predictor of economic opportunity. A Deloitte study in 2021 demonstrated that a 10% increase in broadband access in 2014 would have resulted in more than 875,000 additional U.S. jobs and $186 billion more in economic output in 2019. It enables entrepreneurs and small businesses to leverage digital tools and services and expand their markets. With high-speed broadband access, entrepreneurs and small business owners can reach a wider audience and participate in e-commerce activities. This, in turn, helps create jobs, increase local tax revenue, encourage high-tech industries to enter and invest in the region, and stimulate the local economy long-term.

- **Education:** Broadband access is pivotal for pre-K to adult students/learners and educators as it enables remote learning and access to online educational resources, such as pre-recorded courses, research, and/or attending virtual classrooms. Backed by findings demonstrated in the same report by Deloitte, the report notes that broadband can allow for greater access to formal education. With high-speed broadband access, students can participate in degree-completion programs, certificate programs, or professional education opportunities directly impacting the training quality of the workforce needed for high-tech industries.

- **Healthcare:** Broadband access is increasingly essential in healthcare. High-speed internet availability makes remote access to clinical services possible and cost-effective. It allows patients to access telemedicine services, including remote consultations with doctors, online health monitoring, and prescription delivery. Furthermore, it enables physicians to monitor their patients through innovative home health services. Given rural communities' existing burdens in healthcare facilities and specialized health services high-speed broadband expansion in access is especially critical. Impact of the pandemic on mental health and especially youth mental health, further exacerbated the accessibility and need of physicians and therapists.

- **Civic Participation:** Broadband access is a crucial factor in enabling democratic participation and civic engagement while also helping promote government transparency and accountability in decision making whether they be city, state, or federal bodies. It allows citizens to access government services and information, stay informed about current events, and participate in public meetings remotely to connect with their communities. For government agencies, broadband access improves the quality of communication with local residents and lowers staffing hours and resources dedicated, thus enhancing their offices' productivity.

Broadband infrastructure, access, and awareness helps bridge the Digital Divide by extending equal opportunities for all citizens, regardless of location or socioeconomic background.

# TYPES OF BROADBAND TECHNOLOGY

Broadband technology enables data transmission over high-speed internet connections, allowing users to access and relay vast amounts of information rapidly. Unlike the traditional dial-up, which operates on a narrowband, low-speed connection, broadband boasts higher speeds and enhanced bandwidth. This facilitates faster internet browsing, streaming, and downloading. The technology can be delivered through diverse mediums, including cable, fiber-optic, DSL, and satellite.

While one primary use of broadband is internet access, not all internet connections qualify as broadband. Broadband was historically identified as any connection faster than traditional dial-up. Its defining features are its high speed and constant availability, setting it apart from dial-up, which was not only slower but also on-demand. With broadband's clear superiority over dial-up, the emphasis has shifted to identifying the most advanced broadband technologies based on speed and availability.

## Broadband Technology: Digital Subscriber Line (DSL)

DSL is a wireline transmission technology that operates over copper telephone lines formerly used for analog telephones, fax machines, and dial-up modems. DSL-based broadband provides transmission speeds ranging from several hundred kilobits per second (kbps) to millions of bits per second (Mbps). The availability and speed of DSL service depends on the distance from a home or business to the closest telephone company facility. The following are types of DSL transmission technologies:

**The following are types of DSL transmission technologies:**

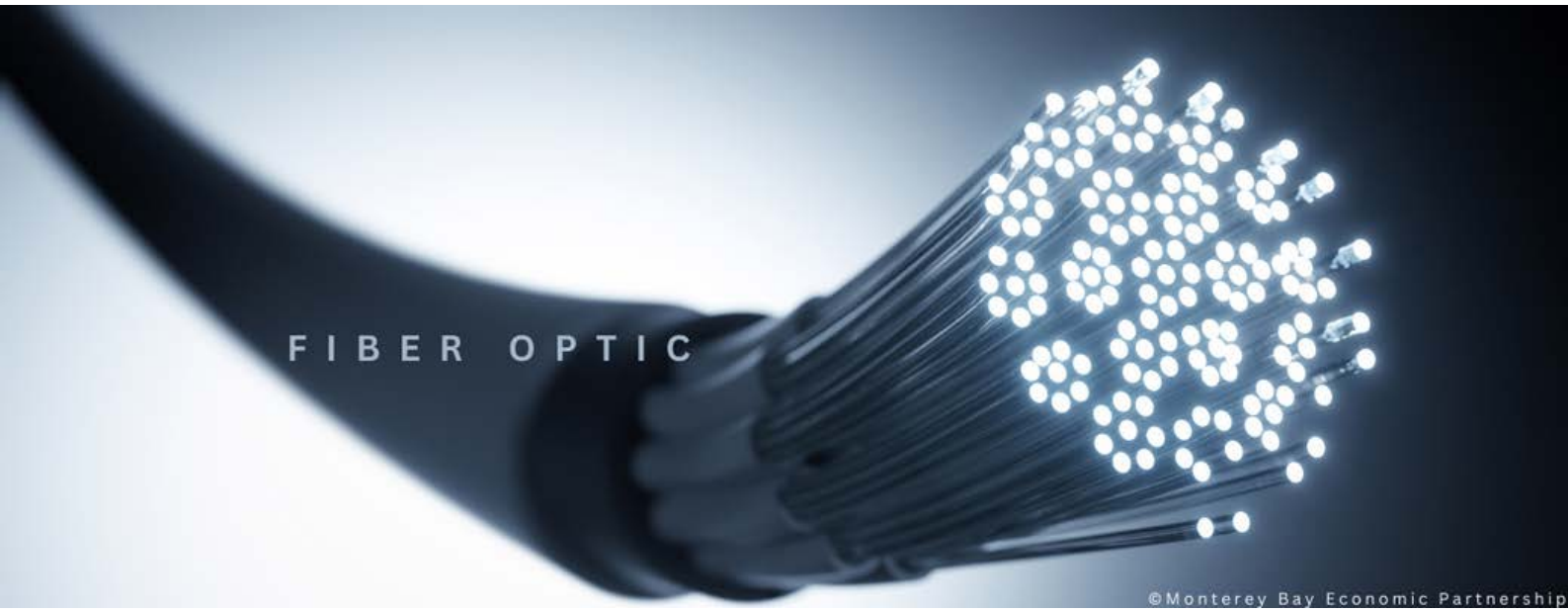
- **Asymmetric Digital Subscriber Line (ADSL)** - Used primarily by residential customers who typically download more data than they upload, ADSL provides faster throughput in the downstream direction, as compared to its upstream capacity. ADSL allows data transmission to coexist on the same copper line that carries analog telephone service.

- **Symmetric Digital Subscriber Line (SDSL)** - Used typically by businesses for services such as video conferencing, which need significant upstream and downstream bandwidth.

Faster forms of DSL typically available to businesses include: High data rate Digital Subscriber Line (HDSL) and Very High data rate Digital Subscriber Line (VDSL). [1]

## Broadband Technology: DOCSIS Cable

Cable modem service enables cable operators to provide broadband using the same coaxial cables that deliver pictures and sound to TV sets. Subscribers can access their cable modem by turning on their computers without dialing up an ISP. Subscribers also enjoy the added capability to watch cable TV while using it. Transmission speeds vary depending on the type of cable modem, cable network, and traffic load. DOCSIS Cable service enables cable television operators to provide broadband using the same coaxial wiring that delivers television entertainment. DOCSIS cable modems are external devices that convert between DOCSIS signals and either Ethernet or Wi-Fi. Subscribers can access the cable network without telephone lines—cable network operators often offer telephone service as part of their cable broadband packages. Data throughput varies measurably based on the cable modem type, the DOCSIS generation available at the subscriber location, and network loading from other users. DOCSIS Cable typically provides download speeds of 100 Mbps or more and upload speeds of 20 Mbps or more.




## Broadband Technology: Fiber

Fiber Gigabit Passive Optical Network (GPON), commonly referred to as simply Fiber, is a type of internet connection that utilizes fiber-optic cables to carry data. Unlike traditional broadband connections that rely on copper wires, fiber broadband uses glass or plastic fibers that transmit information using light. This technology allows faster and more reliable internet speeds, making it the preferred option for deploying fiber broadband to residential users. The fiber-optic cables used in fiber broadband are composed of a collection of strands of glass or plastic. These fibers can transmit data at extremely high speeds. Because they use light to

[1] *In recent years, most residential DSL in urban areas is now VDSL.*

transmit data, they are not subject to interference from other electrical signals. This unique trait means fiber broadband can provide more stable and consistent internet speeds even during peak usage. This broadband technology has several advantages over traditional broadband connections. One of the main benefits is its speed. Fiber broadband can provide internet speeds of up to 1 Gbps, significantly faster than the throughput of copper wire or coaxial connections. In addition, fiber broadband is also more reliable, as it is not subject to interference from other electrical signals. The dependability aspect makes it a better option for businesses and working professionals, requiring a stable and consistent internet connection to operate efficiently. It is further vital to consider the following aspects when considering fiber broadband:

- Fiber optic technology converts electrical signals carrying data to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by tens or even hundreds of Mbps.
- The actual speed the consumer experiences will vary depending on a number of factors, such as how close to the computer the service provider brings the fiber and how the service provider configures the service, including the amount of bandwidth used. The same fiber providing consumer broadband can simultaneously deliver voice (VoIP) and video services, including video-on-demand.
- Telecommunications providers offer fiber broadband in limited areas and continue to announce plans to expand their fiber networks and offer bundled voice, internet access, and video services.
- Variations of the technology run the fiber to the customer's home or business, the curb outside, or a location between the provider's facilities and the consumer.

## *Dark Fiber*

Fiber technology includes "Dark Fiber," often termed unlit or black fiber. Dark Fiber remains unlit because it doesn't yet carry light pulses, and telecommunications or network communication entities usually lay it in anticipation of future need. Dark Fiber agreements govern the leasing of fiber optic cables from, or to, network providers without the cables being owned by standard carriers. Interestingly, even when used by a lessee, a cable can still be labeled "dark" if the cable's owner doesn't utilize it.

Telecommunication infrastructure companies often install more fiber-optic cables than immediately needed, ensuring they can accommodate future data growth in their dark fiber networks. Public Works departments and transportation agencies sometimes lay Dark Fiber while constructing roads, bicycle paths, light rail lines, or during major retrofit of the same. Several configurations exist for setting up Dark Fiber networks, with point-to-point and point-to-multipoint being predominant. Dense Wavelength Division Multiplexing (DWDM) has significantly advanced Dark Fiber by allowing multiple data signals to coexist in the same optical fiber.

While consumers can purchase Dark Fiber affordably, its bandwidth often serves organizations with high-demand broadband connections. Businesses, government agencies, educational

institutions, and e-commerce platforms, among others, can particularly benefit. These entities often handle large, sensitive data files, requiring robust and secure internet capabilities. Dark Fiber offers extensive capacity and impeccable signal strength, transmitting data using light pulses, typically underground. Clients, rather than network providers, control these independent networks. Thousands of miles of unused Dark Fiber stretch across the U.S., much of which was laid but remained "unlit" after the dot-com bubble's burst in the early 00's. With a surge anticipated in construction due to 5G adoption and significant federal and state investments in broadband, the demand for fiber connectivity is poised to skyrocket in the near future.

## Broadband Technology: Fixed Wireless

Fixed Wireless broadband refers to high-speed internet access transmitted wirelessly to subscriber sites. It utilizes radio frequencies to transmit data signals between a wireless access point or router and a user's device. Wireless broadband operates on a range of frequencies, some licensed and some unlicensed. The most common frequency bands for unlicensed wireless broadband are the 5 GHz U-NII bands, which offer high data transfer rates over reasonable distances. The most common bands for licensed wireless broadband are 11 GHz, 60 GHz, and 70 GHz, with the higher frequencies for short-hop connections. Wireless broadband can be delivered through commercial cellular technologies such as 5G, with varying performance based on the distance between the subscriber and the tower and the frequency bands used.


Fixed Wireless broadband refers to high-speed internet access transmitted wirelessly to subscriber sites. It utilizes radio frequencies to transmit data signals between a wireless access point or router and a user's device. Wireless broadband operates on a range of frequencies, some licensed and some unlicensed. The most common frequency bands for unlicensed wireless broadband are the 5 GHz U-NII bands, which offer high data transfer rates over reasonable distances. The most common bands for licensed wireless broadband are 11 GHz, 60 GHz, and 70 GHz, with the higher frequencies for short-hop connections. Wireless broadband can be delivered through commercial cellular technologies such as 5G, with varying performance based on the distance between the subscriber and the tower and the frequency bands used.

Wireless technologies have quickly become a fundamental part of our daily life in the 21st century (Witkowski, 2019). One of the main advantages of wireless broadband is its mobility. With wireless broadband, users can access the internet from anywhere within the range of a wireless access point without needing physical cables or wires. The improved access makes it ideal for use in

environments where mobility is essential, such as airports, coffee shops, and public transportation. Additionally, wireless broadband can be easily installed and set up, making it a popular choice for home and small business users in rural communities with limited fiber infrastructure. It is crucial to consider the following facts when adopting wireless as a form of broadband technology:

- Wireless broadband connects a home or business to the internet using a radio link between the customer's location and the service provider's facility. Wireless broadband can be mobile or fixed.
- Wireless technologies use longer-range directional equipment to provide broadband service in remote or sparsely populated areas where DSL or cable modem service would be costly. Speeds are generally comparable to DSL and cable modem, and an external antenna is usually required.
- Wireless broadband internet access services offered over fixed networks allow consumers to access the internet from a fixed point while stationary, often requiring a direct line-of-sight between the wireless transmitter and receiver. For example, thousands of small Wireless Internet Services Providers (WISPs) provide wireless broadband at speeds of around one Mbps using unlicensed devices, often in rural areas not served by cable or wireline broadband networks.
- Wireless Local Area Networks (WLANs) provide wireless broadband access over shorter distances. They are often used to extend the reach of a Last-Mile wireline or fixed wireless broadband connection within a home, building, or campus environment. Wi-Fi networks use unlicensed devices and can be designed for private access within a home or business or public internet access at hot spots such as restaurants, coffee shops, hotels, airports, convention centers, and city parks.
- Mobile wireless broadband services are also becoming available from mobile telephone service providers and others. These services are generally appropriate for highly mobile customers and require a special PC card with a built-in antenna that plugs into a user's laptop computer. Typically, they provide lower speeds in the range of several hundred kilobits per second.

## Broadband Technology: Broadband Over Powerline (BPL)

Broadband over powerline (BPL) technology facilitates internet access via existing electrical power lines. By employing Orthogonal Frequency Division Multiplexing (OFDM), BPL modulates the datastream into multiple frequencies, which are then imposed onto electrical lines, enabling the simultaneous transmission of data and electricity. As a result, BPL offers high-speed internet in areas where traditional wired or wireless solutions might be impractical. Key advantages of BPL include its elimination of the need for extra wiring or infrastructure, which often incurs significant costs and installation time. Furthermore, given the durability of power lines compared to other mediums, BPL often promises more reliable internet access. With speeds reaching up to 200 Mbps, it's apt for high-demand tasks like video streaming.

However, BPL is not without challenges. Like any xDSL and DOCSIS cable, it can suffer

interference from nearby sources of electromagnetic interference, potentially affecting speed and connection quality. And while it offers an innovative solution in some scenarios, its compatibility with specific electrical systems may limit its widespread adoption. At scale, BPL requires the cooperation of, and coordination with, a municipal or investor-owned utility.

### *Satellite Broadband*

Just as satellites orbiting the Earth provide vital links for telephone and television services, they can also provide links for broadband. Satellite broadband is another form of valuable wireless broadband for serving remote or sparsely populated areas. Downstream and upstream speeds for satellite broadband depend on several factors, including the provider and service package purchased, the consumer's line of sight to the orbiting satellite, and weather conditions. The availability and speed of DSL service depend on the distance from a home or business to the closest telephone company facility. Traditional satellite broadband service can be easily disrupted in extreme weather conditions and routinely may experience high latency and interference that impact speeds and reliability. It should be noted that new satellite internet constellations are being developed in low-earth orbit to mitigate the long-standing shortcomings of satellite technology. Despite other technologies demonstrating advantages in reliability and available speeds, satellite internet is still a vital tool for bridging the Digital Divide, as it can reach remote or rural areas that do not permit access to deploy fiber, cable, or BPL internet connections.

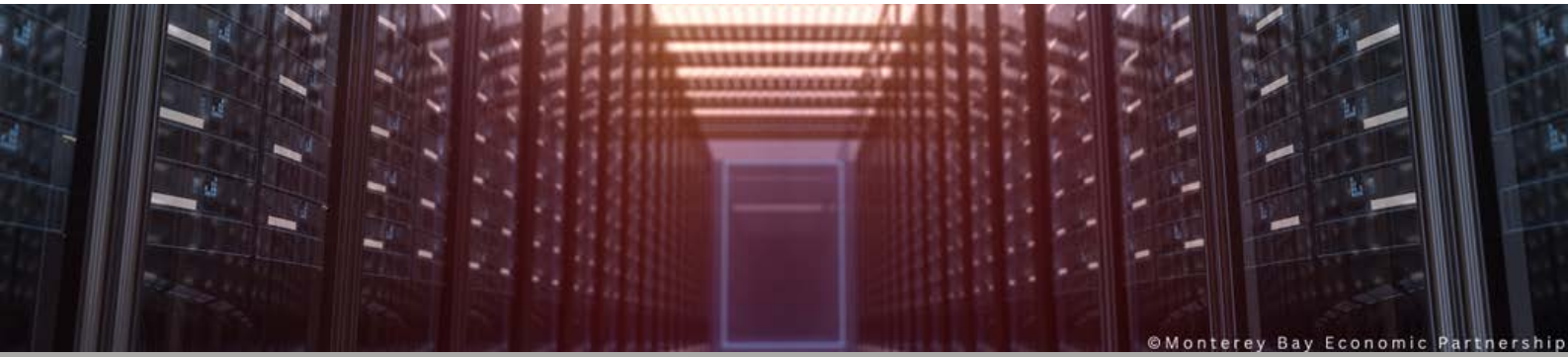
# COMPARISON OF BROADBAND TECHNOLOGIES

Bridging the Digital Divide in the Monterey Bay region is complex and daunting. It requires a comprehensive approach that involves technological expertise and guidance, local government support, and community engagement. Furthermore, all three counties in the region have contrasting Digital Equity needs among one another and within their own communities. Each community's existing investments in infrastructure, awareness, and access play a vital role in defining the strategic planning necessary to identify the suitable broadband technology(s) and the required strategic planning to carry out its deployment to best serve its communities' short-term and long-term needs.

Whether it's assessing the differences across counties, rural and urban areas, neighboring municipalities, or public/private network ownership structures, what is apparent is the seemingly countless factors to consider when attempting to fill gaps and provide access to local residents' businesses is that no one technology can do it all on its own. Thus, it serves as a reminder that comparing various broadband technologies and weighing their suitability based on their assumed benefits and disadvantages in the project development phase remains necessary for government offices and agencies.

Broadband technologies differ in speed, reliability, cost, and availability capacities. Therefore, comparing them can help local governments, community-based organizations, and residents find the service that best meets their requirements.

- **Cost:** Broadband services can vary widely, so comparing different technologies can help users find the most cost-effective option.
- **Speed:** Broadband speeds can significantly impact user experience, so comparing different technologies can help users find the fastest option available in their area.
- **Reliability:** Some broadband technologies may be more reliable, especially in areas with inclement weather or other potential disruptions. Comparing different technologies can help users find the most reliable option.
- **Availability:** Broadband technologies may not be available in all areas, so comparing different options can help users find the available services.



Among the discussed categories that determine the suitability of broadband technology, establishing a standard for broadband access through an emphasis on speed impacts the ultimate decision. Depending on financial investments by region-focused ISPs, the top three broadband preferences are cable, fiber, and wireless. Cable, which consists of a copper core insulated with aluminum, is susceptible to weather events due to its reliance on electricity. Monterey, San Benito, and Santa Cruz counties, sensitive to devastating climate shocks, regularly experience electric outages and undergo regular periods without broadband access in residential and business areas, negatively impacting local economies. Given the growing threat and vulnerability of all three counties to natural shocks caused by man-made climate change, forward-thinking and preparation are necessary by counties and municipalities to ensure they promote resilient broadband solutions that address communities' infrastructure, awareness, and access needs by prioritizing the area's susceptibility to natural disasters.

The current download and upload standards according to the California Public Utilities Commission (CPUC), Federal Communications Commission (FCC), and Monterey Bay Economic Partnership are:

| | Download | Upload |
|---|---|---|
| **State of California (current law)** | 10 Mbps | 1 Mbps |
| **Gubernatorial Executive Order & CPUC** | 100 Mbps | 20 Mbps |
| **FCC (current law)** | 25 Mbps | 3 Mbps |
| **U.S. Congress (via IIJA) & NTIA** | 100 Mbps | 20 Mbps |
| **Monterey Bay Economic Partnership** | 100 Mbps | 20 Mbps |

Upon exploring broadband technologies and their various speed capabilities, fiber-optic stands out as having speeds about five times faster than regular cable at one gigabit. Fiber-optic technology carries more data than copper cables, giving consumers a significantly faster, more reliable broadband connection that has become a daily requirement in the post-COVID-19 era. California legally defines broadband as internet service with minimum speeds of 10 Mbps download and 3 Mbps upload, while the Governor (via Executive Order) sets a standard of 100/20 Mbps. The Monterey Bay regional broadband standard was determined to be 100/20 Mbps based on primary research completed in 2018. These speeds meet homes' and businesses' needs and use cases today. It is anticipated that higher gigabit speeds will be needed in the near future as the post-COVID era continues to demand more advanced broadband access.

## Fiber and Cable Technology

While both fiber and cable connections offer fast internet speeds and reliable connections, there are some critical differences between them. The below information highlights differences between cable and fiber broadband in terms of speed, reliability, cost, and availability:

- **Availability:** Cable broadband is more widely available than fiber broadband. Cable infrastructure is already in place in many areas, while fiber-optic infrastructure is still being deployed. To bring the discussion to the Monterey Bay region, much of its scarcity in fiber-optic access is attributed to the lack of infrastructure.


- **Speed:** Cable and fiber broadband offer high-speed internet connections, but fiber broadband is generally faster. Fiber broadband can provide speeds of up to 1 gigabit per second (Gbps), while cable broadband typically tops out at around 300 megabits per second (Mbps). The difference in speed is because fiber-optic cables are made of glass or plastic, allowing data to be transmitted faster than coaxial cables used in cable broadband.

- **Reliability:** Fiber broadband is generally more reliable than cable broadband. This reliability is because fiber-optic cables are less susceptible to interference from electrical signals or other types of interference. Cable broadband connections can be affected by bad weather, which can cause interruptions in service. Fiber broadband is also less likely to experience downtime during peak usage times.

- **Cost:** Fiber broadband is generally more expensive than cable broadband. The cost of fiber-optic infrastructure is higher than that of cable infrastructure, and that cost is passed on to the consumer. However, prices for fiber broadband have been dropping as the technology becomes more widely available, along with the availability of state and federal funding programs.

## Fiber and Fixed Wireless Technology

Fiber broadband technology is generally faster and more reliable than wireless broadband, but it is also more expensive and less accessible to rural communities. On the other hand, wireless broadband is less costly and more accessible to rural communities, but it is also slower and less reliable than fiber-optic broadband. In terms of coverage, both fiber-optic and wireless broadband have limitations. Fiber-optic broadband is typically only available in urban or suburban areas where the infrastructure has been installed. Wireless broadband, while more accessible to rural communities, is limited by the range of cellular towers or satellite signals. The below information highlights differences between wireless and fiber broadband in terms of speed, reliability, cost, and availability:

- **Availability:** Fiber broadband has yet to be widely available, especially in rural areas in the region, and requires significant infrastructure investments to bring it to new places. In contrast, wireless broadband is more widely available and can be accessed through cellular networks or satellite connections. However, the availability of wireless

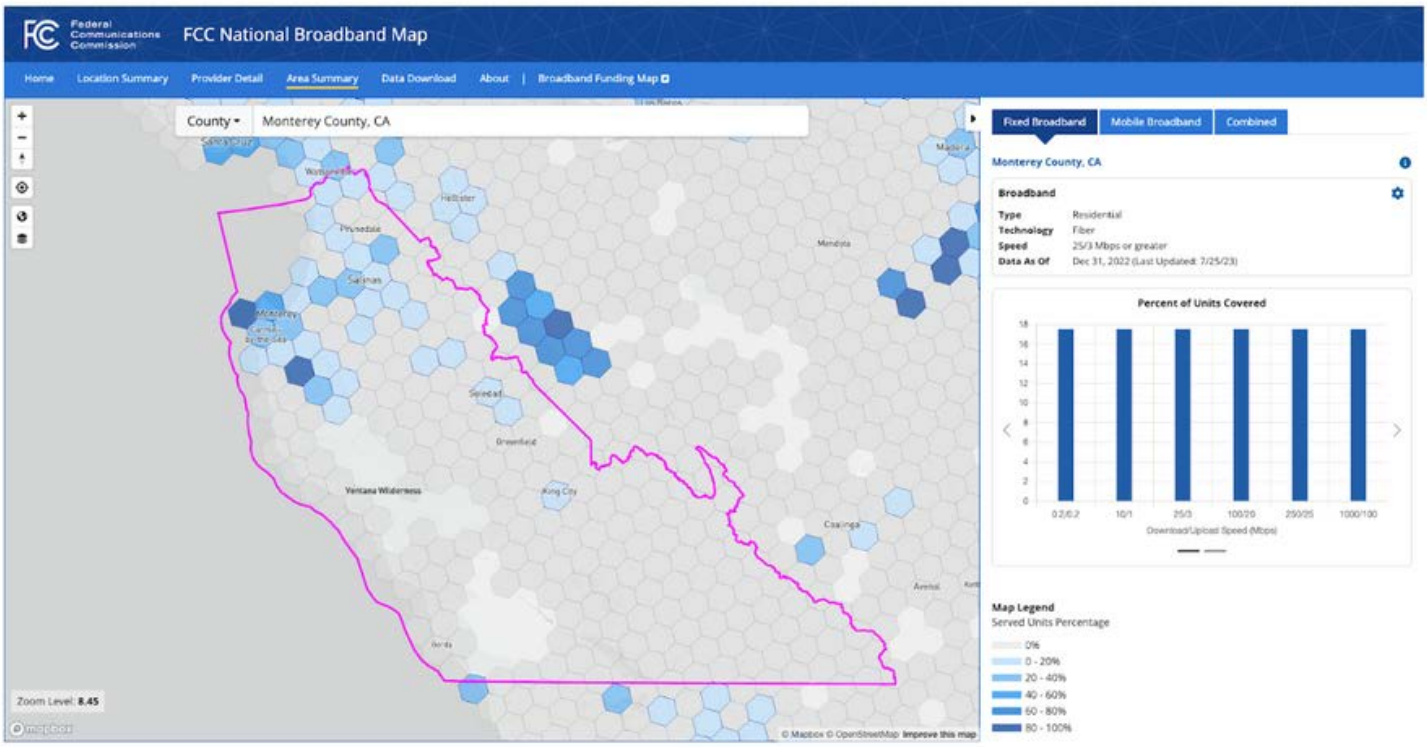
broadband can be limited in certain areas, such as buildings with thick walls or remote locations with weak signals.

- **Speed:** Fiber broadband offers the fastest internet speeds, with download and upload speeds ranging from 100 Mbps to 1 Gbps or more. This speed is consistent even during peak usage times, as fiber-optic cables transmit data at the speed of light. In contrast, wireless broadband speeds can vary depending on the signal strength and distance from the wireless tower. Generally, wireless broadband speeds range from 5 Mbps to 100 Mbps.
- **Reliability:** Fiber broadband is more reliable than wireless broadband since fiber-optic cables are unaffected by external factors such as weather, interference, or signal congestion. On the other hand, wireless broadband is more susceptible to interference from physical obstacles such as walls, trees, or buildings. Additionally, other wireless devices in the area can affect wireless broadband signals, leading to signal congestion and slower speeds.
- **Cost:** Fiber broadband is generally more expensive than wireless broadband due to the higher infrastructure costs required to lay fiber-optic cables. Fiber broadband plans often come with data caps or other restrictions that can further drive the price. On the other hand, wireless broadband plans are typically less expensive and often come with unlimited data plans.

According to the FCC Broadband Map, the following maps indicate fiber access reports for Monterey, San Benito, and Santa Cruz counties for residential and business access as of July 25, 2023. The reports suggest that many tri-county communities need access to fiber for residential and business use. The promise of fiber access would be evidence for faster, more reliable, standardized download and upload speed and quality as recommended by the CPUC. Similarly, the evidence showcased in the maps indicates that the highest fiber coverage available to all three counties remains between 0-20%. It is also important to note that some areas of Monterey, San Benito, and Santa Cruz counties have access to cable and wireless rather than fiber. However, this access needs to be revised for download and upload speed. While many ISPs seem to offer fiber access and adoption plans for residential and business consumers, there is visible incongruity as consumers experience a sudden change in broadband speed and type of service upon the activation of their contract; what is advertised and promised as high-speed fiber connection is revised and delivered as low-speed/quality cable service due to lack of fiber in large areas of both counties.

# BROADBAND COVERAGE

The Federal Communications Commission (FCC) regulates interstate and international communications through cable, radio, television, satellite and wire and provides maps of broadband fiber coverage for both residential and commercial coverage. The California Public Utilities Commission (CPUC) also provides maps. MBEP reviews county-level maps in collaboration with ISP, community, city, school district, business, and advocates to push for policies and funding proposals to leverage resources for infrastructure, awareness, and access. Below FCC map is an example of fiber for Monterey County.




The coverage maps show reported, not actual, coverage and speed from ISPs for residential and business consumers. It should be noted that even if one broadband user in a particular census block has service and others do not, both the FCC and CPUC will consider that census block served. A designated served census block is not eligible for CPUC grants to upgrade infrastructure and increase speeds. As a result, the coverage maps represent a best-case scenario, not a realistic view.

## *FCC Data: Broadband Coverage*

| | Fiber Served | Fiber Underserved/ Unserved | Fixed Wireless Served | Fixed Wireless Unserved/ Unserved |
|---|---|---|---|---|
| **Monterey (Business)** | 17.97% | 82.03% | 90.62% | 9.38% |
| **Monterey (Residential)** | 17.54% | 82.46% | 91.25% | 8.75% |
| **San Benito (Business)** | 8.01% | 91.99% | 96.31% | 3.69% |
| **San Benito (Residential)** | 8.30% | 91.70% | 96.31% | 3.69% |
| **Santa Cruz (Business)** | 24.94% | 75.06% | 50.37% | 49.63% |
| **Santa Cruz (Residential)** | 24.70% | 75.30% | 54.17% | 45.83% |

*Data As Of December 31, 2022 (Last Updated: 07/25/2023)*

The above table showcases the percentages of served and unserved/underserved residential and business entities in Monterey, San Benito, and Santa Cruz counties, emphasizing two broadband technologies suitable for the region: fiber and wireless. As reported by the FCC, there is a significant difference between the total served entities with fiber technology as opposed to fixed wireless technology. The rural nature of numerous communities within the tri-county area has contributed to the limited or lack of the infrastructure needed for fiber technology, leaving many residential and commercial community members needing more reliable broadband service.

# WHERE DOES FIXED WIRELESS COME IN?

As showcased in the FCC maps, a small percentage of the tri-county area in the Monterey Bay region has access to high-speed fiber technology, as the needed infrastructure is only available in some of the rural communities in the region. In order to connect residential and commercial entities to reliable broadband service without access to fiber technology, wireless may be considered a secondary option. Wireless technology can be particularly advantageous for rural communities in Monterey, San Benito, and Santa Cruz counties that lack the necessary infrastructure to support traditional wired broadband connections.


One of the main benefits of wireless broadband for rural communities is its flexibility and ease of installation. Unlike wired broadband, which requires extensive infrastructure to be installed, wireless broadband can be deployed quickly and easily without significant infrastructure investments. This means that remote and rural communities that lack access to fiber-specific broadband infrastructure can quickly be connected to the internet through wireless broadband networks. One of the key advantages of wireless broadband is its scalability. Wireless broadband can be deployed in areas with varying demand levels, allowing service providers to adjust their network capacity based on usage patterns. This means that rural communities can access reliable internet services without significant investment in infrastructure or ongoing maintenance costs. This technology can also provide faster and more reliable internet speeds than traditional wired broadband. This is because wireless broadband can bypass the limitations of wired infrastructure, which can often be costly to maintain and upgrade. Using wireless technology, rural communities can access faster internet speeds, improving their quality of life by directly investing in their local economy and participating in online education, entrepreneurship, local government, social and civic engagement, healthcare, and other services. Wireless broadband's flexibility, scalability, and reliability make it an ideal solution for connecting unserved and underserved communities to the internet. Therefore, the benefits of wireless broadband technology may be summarized as follows:

- **Convenience:** Wireless broadband provides added convenience by eliminating the need for cables and wires, thus enabling users to connect to the internet from anywhere. With wireless broadband, users can access the internet from their smartphones, tablets, and laptops without being tethered to a desk.
- **Mobility:** Wireless broadband offers mobility, which means that users can access the internet on the go. This is particularly useful for people only sometimes in one location, such as travelers, students, and business professionals. Wireless broadband enables users to access the internet from their devices in public places, such as coffee shops, libraries, and airports.
- **Cost-Effective:** Wireless broadband is cost-effective compared to fiber broadband. It eliminates the demand for expensive infrastructure and equipment, such as cables and routers. Moreover, wireless broadband providers offer various packages catering to different budgets and needs.
- **Accessibility:** Wireless broadband is accessible to more people than wired internet connections. This is because it does not require the installation of physical infrastructure, such as cables and wires, which can be expensive and time-consuming. Wireless broadband enables users in remote areas to access the internet, which is impossible with wired connections.
- **High-Speed:** Wireless broadband is accessible to more people than wired internet connections. This is because it does not require the installation of physical infrastructure, such as cables and wires, which can be expensive and time-consuming. Wireless broadband enables users in remote areas to access the internet, which is impossible with wired connections.

Meanwhile, there are apparent disadvantages to choosing wireless broadband over fiber. These limiting factors include:

- **Signal Interference:** Other electronic devices can interfere with wireless broadband signals. This can result in slower internet speeds and poor connectivity.
- **Limited Range:** Wireless broadband has limited range, which means that users need to be within a certain distance from the access point to access the internet. This can be a challenge in large buildings and open spaces.
- **Security:** Wireless broadband is vulnerable to security breaches like hacking and identity theft. Unauthorized users can intercept and manipulate wireless signals, making its cyber security model uniquely vulnerable.
- **Reliability:** Wireless broadband connectivity can be unreliable in areas with poor signal strength. This can result in constant slower internet speeds and dropped connections.
- **Cost:** Although wireless broadband is generally advertised as cost-effective, it can be expensive in some remote regions, mainly rural communities. This is due to wireless broadband providers' need to invest in infrastructure and equipment to provide reliable connectivity in unserved and underserved areas.

# THE HYBRID BROADBAND MODEL


In the Monterey Bay region, where areas remain unserved or underserved due to limited or no fiber broadband infrastructure, it's recommended to introduce a Hybrid Broadband Model. This model, grounded in up-to-date location data and infrastructure analysis, would cater to both residential and commercial entities.

The Hybrid Broadband Model proposes a blend of fiber optic and wireless broadband solutions, tailored to each location's infrastructure capabilities. Importantly, it ensures ISPs cannot neglect unserved areas because of funding limitations. If fiber technology isn't feasible for certain locales, the model would mandate ISPs to provide a wireless alternative. This approach addresses concerns where Last-Mile projects remain unfunded due to discrepancies in the CPUC map that fail to highlight specific unserved zones.

Wireless broadband stands as a potent tool to close the Digital Divide, ensuring regions with sparse or no infrastructure aren't denied access to reliable broadband. By adopting the Hybrid Broadband Model, local governments, the regional broadband consortium, and ISPs are held accountable to either offer fiber optic or wireless broadband solutions. Such a commitment ensures that communities can fully engage in their local economies. If a location lacks the requisite infrastructure for fiber, the model's default recommendation is to provision it with wireless technology.

# RECOMMENDATIONS

## Recommendations for Fixed Wireless Technology

The following are recommendations for adopting fixed wireless broadband in unserved and underserved communities in the Monterey Bay region:

- **Collaboration between Local Governments and ISPs:** Both parties should partner to prioritize and establish wireless broadband infrastructure in unserved and underserved areas lacking fiber infrastructure. This can include setting up towers, base stations, and essential equipment for wireless internet. To encourage ISP investments, local governments might offer subsidies or tax incentives. Additionally, ISPs should liaise with communities and the regional broadband consortium to identify optimal infrastructure locations, ensuring rural areas aren't overlooked.

- **Community Outreach and Education:** Awareness and understanding of wireless broadband are pivotal for its adoption in rural settings. Given potential concerns about cost, security, or the benefits of high-speed internet, local governments and ISPs should organize community workshops. These events can elucidate the merits of wireless broadband, allay concerns, and clarify the distinctions between fiber and wireless technologies.

- **Affordability Initiatives:** To make wireless broadband accessible for rural residents and small businesses, policies might be instituted to reduce costs. Options could encompass discounted rates, subsidies for qualifying households and businesses, or other affordability measures.

- **Community Broadband Programs:** Local governments could collaborate with ISPs to finance community-driven broadband initiatives targeting underserved locales. Such programs reinforce the belief that internet access is a universal need, ensuring all community members can reap its advantages and, in turn, bolster the local economy.


## Recommendations for Fiber-Optic Technology

While fiber broadband is a vital resource providing fast and reliable internet connectivity, many rural communities in the Monterey Bay region are still underserved because of limited access to or a lack of infrastructure. To ensure that these communities have access to the many benefits of fiber broadband, several recommendations should be considered:

- Establish a public-private partnership that can work alongside the regional broadband consortium and broadband JPA to expand fiber broadband infrastructure in rural areas equitably. This may involve collaborating with local internet service providers (ISPs) and telecommunications companies to help fund the construction of fiber-optic cables, which can be costly in rural areas. Public funding can incentivize these companies to expand their service areas and install fiber-optic lines in rural areas, benefiting both the community and the companies.
- Educate rural residents about the benefits of fiber broadband and how it can positively impact their lives. This can be done through targeted marketing campaigns that showcase the advantages of faster and more reliable internet access. It is also essential to provide digital literacy and support to rural residents on how to use the internet for business, telehealth, education, civic participation, and other vital tasks to contribute to the local economy. This can help bridge the Digital Divide and give rural residents the tools they need to succeed.
- Policymakers should consider regulatory changes that can require the expansion of fiber broadband in rural areas. Currently, all funding opportunities allow ISPs to decline remote regions that lack infrastructure by focusing on existing infrastructure and the state-funded Middle-Mile project. Regulatory changes can include changes to zoning laws that allow for the construction of new fiber-optic lines and changes to licensing requirements that make it easier for ISPs to operate in rural areas. In addition, policymakers can provide tax incentives for companies that expand their broadband infrastructure in rural areas, incentivizing further investment and promoting economic development.

## Summary

In essence, introducing the Hybrid Broadband Model or fiber-optic technology to rural underserved areas necessitates a comprehensive strategy. This approach should champion continuous collaboration between public and private sectors, bolstered by education and outreach in rural communities. It's crucial to have supportive policies and regulations in place that drive broadband infrastructure investments and ensure no community remains overlooked. By opting for one of these recommended strategies, we can guarantee that every community in the Monterey Bay region benefits from consistent and high-speed broadband, enriching the region's evolving economy.

# GLOSSARY OF TERMS

**ACP - Affordable Connectivity Program:** is an FCC benefit program that helps ensure that households can afford the broadband they need for work, school, healthcare and more. The benefit provides a discount of up to $30 per month toward internet service for eligible households and up to $75 per month for households on qualifying Tribal lands. Eligible households can also receive a one-time discount of up to $100 to purchase a laptop, desktop computer, or tablet from participating providers if they contribute more than $10 and less than $50 toward the purchase price. The Affordable Connectivity Program is limited to one monthly service discount and one device discount per household. *Retrieved from Federal Communications Commission*

**ADSL - Asymmetric Digital Subscriber Line:** is a form of Digital Subscriber Line (DSL) service with a larger portion of capacity devoted to downstream communications, and less to upstream. Typically thought of as a residential service. *Retrieved from National Telecommunications and Information Administration & Federal Communications Commission*

**Backbone:** Long Haul/Backbone - are massive networks with national and major regional reach. The networks run to buildings that act as exchange points, where data is passed between and across regional and local networks and providers. These are typically located in the larger metropolitan areas, including One Wilshire in downtown Los Angeles. Long Haul or backbone networks are analogous to interstate highways. *Retrieved from Techopedia & Office of Educational Technology & California Community Foundation*

**Bandwidth:** is typically used to describe the capability of telecommunications and internet networks to transmit data and signals in a given amount of time; usually measured in bits per second, kilobits per second, and megabits per second. In the world of internet service, bandwidth has come to mean the speed of internet service, measured in bits per second. The rate at which the network can transmit information. *Retrieved from CPUC & Center for Rural Policy & Development*.

**Broadband:** is commonly referred to as high-speed internet access that is always on and faster than the traditional dial-up access. Broadband includes several high-speed transmission technologies such as Digital Subscriber Line (DSL), Cable Modem, Fiber, Wireless, Satellite, Broadband over Powerlines (BPL), etc. "Broadband" is generally shorthand for quality internet service. The State of California currently defines broadband as internet service with minimum speeds of 25 Mbps download/3 Mbps upload. *Retrieved from FCC, California Community Foundation & Center for Rural Policy & Development*.

***Broadband Adoption:*** *denotes the use of broadband in places where it is available, measured as the percentage of households that use broadband in such areas. When a household has a broadband subscription, they have "adopted" or are putting to use their access to broadband. Broadband adoption is daily access to the internet: (1) At speeds, quality and capacity necessary to accomplish common tasks, (2) With the digital skills necessary to participate online, and (3) On a personal device and secure, convenient network. Retrieved from National Telecommunications and Information Administration (NTIA) & National Digital Inclusion Alliance*

**Broadband Connection:** usually refers to broadband's transmission of high-quality data of wide bandwidth. In its simplest form, it is a high-speed internet connection that is always on. Broadband connections include Wi-Fi, DSLs, fiber, and satellites. *Retrieved from FCC , Investopedia & Broadband Search*

**Broadband Equity:** is achieved when all people and communities are able to access and use fast, reliable, and affordable internet that meets their long-term needs. *Retrieved from California Community Foundation & NDIA*.

**Broadband Modem:** is an external device that connects to high-speed internet, such as over a DSL or cable network. The connection is always on and does not require the user to connect before using the internet. *Retrieved from FCC, PCMag, & GCF Global*.

**BPL - Broadband Over Powerline:** is a type of broadband technology that delivers broadband over the existing low- and medium-voltage electric power distribution network. BPL speeds are comparable to DSL and cable modem speeds. BPL can be provided to homes using existing electrical connections and outlets. BPL is an emerging technology that is available in very limited areas. It has significant potential because power lines are installed virtually everywhere, alleviating the need to build new broadband facilities for every customer. *Retrieved from CPUC & FCC*.

**Cable or Cable Modem Service:** is a type of broadband technology that enables cable operators to provide broadband using the same copper coaxial cables that provide television service (similar to the way DSL uses the phone network infrastructure). This type of connectivity model is very common across the United States. Transmission speeds vary depending on the type of cable modem, cable network, and traffic load. Speeds are comparable to DSL. *Retrieved from FCC & Center for Rural Policy & Development*.

**CASF - California Advanced Services Fund:** is an authorized entity and fund, as of 2007 by the CPUC per Public Utilities (P.U.) Code § 701. As of 2021, California Advanced Services Fund is allocated into five CASF accounts - Broadband Adoption Account, Broadband Infrastructure Grant Account, Broadband Public Housing Account, Rural and Urban Regional Broadband Consortia Grant Account, and Line Extension Pilot Program. All of which to reach its stated goal of achieving broadband access to no less than 98% of California households in each consortia region and bridge regional gaps in digital divide. *Retrieved from CPUC*.

**CDT - California Department of Technology:** is the state department assigned by SB 156, along with its Office of Broadband & Digital Literacy that oversees the acquisition and management of contracts for the development, construction, maintenance and operation of the network. CDT also retains a Third Party Ambassador to construct and establish the network and has created a nine-member Middle-Mile Advisory Committee. *Retrieved from CPUC & CDT*.

***Coaxial Cable:*** *A type of cable that can carry large amounts of bandwidth over long distances. Cable TV and cable modem service both utilize this technology. Retrieved from CPUC*.

**CPUC - California Public Utilities Commission:** is the organization mandated by the state Constitution to regulate public utilities in California. *Retrieved from CPUC*.

**CCBC - Central Coast Broadband Consortium:** is a broadband development organization with over a 20-year history in Monterey, Santa Cruz, and San Benito counties. CCBC's efforts focus on developing and supporting broadband projects funded by the CASF Infrastructure Account and broadband deployment projects related to programs created under SB 156 and AB 164. The consortium's goals consist of developing and supporting broadband projects funded by the CASF Infrastructure Grant Account on deployment of open access middle-mile facilities, construction of new and upgraded last-mile infrastructure. CCBC representation comprises local city and county agencies, educational institutions, industry and economic development interests, and community-based organizations. CCBC received approval for three Consortia Account grants: $450,000 in December 2011 (Resolution T- 17349), $274,500 in August 2016 (Resolution T-17529), and $450,000 in October 2019 (Resolution T-17669). Funding granted for CCBC in Resolution T-17669, concluded on October 31, 2022. *Retrieved from CPUC*.

**Dark Fiber:** also known as "un-lit" fiber or black fiber, is an unused optical fiber that has been laid. It is usually used in Telecom and Network Communications. There are thousands of miles of unused dark fiber cables across the U.S. While it is currently unused, it's known to be dark as no light pulses are transmitted through it. In regular fiber cables, light pulses send information, but it's essential that these cables are instead taken advantage of. *Retrieved from NTIA, Office of Educational Technology, Institute for Local Self-Reliance, & Gartner*.

**Dial-Up:** is a technology that provides customers with access to the internet over an existing telephone line. *Retrieved from CPUC*.

**Digital Divide:** is the gap between those of a populace with accessible, affordable, and reliable internet connectivity along with the digital literacy, skills, and support needed to engage online effectively and those of the populace who do not. The Digital Divide has the potential to deepen progressively with each successive generation of technology. *Retrieved from UC Riverside & Internet Society*.

**Digital Equity:** is a condition in which the entirety of the populace and communities have the information technology capacity needed for full participation in our society, democracy, and economy. Digital equity is necessary for civic and cultural participation, employment, lifelong learning, and access to essential services. *Retrieved from NDIA & CPUC*.

**Digital Inclusion:** refers to the actions required to achieve digital equity and ensure that all individuals and communities, including the most disadvantaged, have reliable, accessible, and affordable internet access. Digital Inclusion requires intentional strategies and investments to reduce and eliminate historical, institutional, and structural barriers to accessing and using technology. Using the National Digital Inclusion Alliance as a guide, the NDIA identified 5 Key Elements of Digital Inclusion:

- Affordable, robust broadband internet service;
- Internet-enabled devices that meet the needs of the user;

- Access to digital literacy training;
- Quality technical support;
- Applications and online content designed to enable and encourage self- sufficiency, participation and collaboration.

*Retrieved from NDIA.*

**Digital Literacy:** is defined as the ability to leverage current digital technologies, communications tools, and/or networks to access, manage, integrate, evaluate, create, and communicate information that requires cognitive and technical skills to function in a knowledge society. *Retrieved from NDIA, UC Riverside, CPUC, & US Department of Education*

**Downstream:** also known as download speed, internet connections have two components – downstream and upstream. Downstream refers to the rate at which the user's computer can receive data from the internet. Data flowing from the internet to a computer (Surfing the net, getting Email, downloading a file). *Retrieved from CPUC & FCC*

**DSL - Digital Subscriber Line:** is a form of wireline transmission technology that utilizes a two-wire copper telephone line to allow users to simultaneously connect to and operate the internet and the telephone network without disrupting either connection. DSL transmits data faster over traditional copper telephone lines already installed to homes and businesses. The availability and speed of your DSL service may depend on the distance from your home or business to the closest telephone company facility. Types of DSL include ADSL, SDSL, HDSL, VDSL. *Retrieved from CPUC, FCC & Center for Rural Development and Policy.*

**FCC – Federal Communications Commission:** is a federal regulatory agency that is responsible, among other things, for regulating VoIP. The Federal Communications Commission (FCC) regulates interstate and international communications by radio, television, wire, satellite, and cable in all 50 states, the District of Columbia and U.S. territories. *Retrieved from FCC.*

**Fiber-optic:** is a type of broadband technology that transmits data by sending light along thin glass fibers. Fiber broadband (sometimes called fiber internet) is an internet service that is powered by fiber-optic cables. This is different from traditional cable internet, which transmits information by sending electricity over copper wires. Currently viewed as the "gold standard" of residential internet connections, its biggest benefit comes from offering much faster speeds over much longer distances than traditional copper-based technologies like DSL and cable, and has nearly infinite bandwidth to meet growing needs. *Retrieved from CPUC, Center for Rural Development and Policy & Verizon*

**Fixed Wireless:** Similar to DSL and cable internet, fixed wireless is a "last mile" technology that bridges the relatively short gap between the mainstream internet "backbone" and homes or businesses. Fixed Wireless is a connectivity model that uses stationary wireless transmission to bridge the "last mile" between the internet backbone and the subscriber. The connections occur through the air, rather than through fiber, resulting in a less expensive alternative to a fiber connection. *Retrieved from CPUC, NTIA, & European Commission.*

**FTTN – Fiber To The Neighborhood:** is a hybrid network architecture involving optical fiber from the carrier network, terminating in a neighborhood cabinet which converts the signal from optical to electrical. *Retrieved from CPUC & Technopedia*

**FTTP – Fiber To The Premise (Or FTTB – Fiber To The Building):** is a fiber-optic system that connects directly from the carrier network to the user premises. (typically an MDU), a first-mile infrastructure. Fiber laid all the way to the building. *Retrieved from CPUC & Gartner*

**Hybrid Broadband Model:** is formulated to include both fiber optic and wireless broadband options based on each designated location's infrastructure availability.

**Internet Service Provider (ISP):** is a company that provides users (individuals, businesses, anchor institutions, etc.,) with access (a connection) to the internet. ISPs include telephone and cable companies, wireless ISPs, electric cooperatives, municipal utilities, and mobile wireless providers. ISPs act as a bridge between customer (end-user) and infrastructure owners for dial-up, cable modem and DSL services. ISPs use different technologies, including fiber, cable, DSL, and fixed wireless, to deliver internet service to their customers. *Retrieved from CFF, CPUC, NTIA , & Pew Charitable Trusts*.

**LAN – Local Area Network:** is a geographically localized network consisting of both hardware and software. The network can link workstations within a building or multiple computers with a single wireless internet connection. It is a computer network that interconnects computers within a limited area such as a building or small group of adjacent buildings. *Retrieved from NTIA, Cisco, & califa*

**Last Mile:** is a term used to describe the technology and process that acts as a last link between connecting the end customer's home or business to the local network provider. Typically, Last Mile projects are the most expensive part of the network to build or upgrade because of the number of units involved. *Retrieved from NTIA & Legislative Analyst's Office*

***Latency:*** *is the amount of time it takes for a bit to get from point A to point B. The less data you send, the less time it takes, but there's a limit. No matter how small the amount of data, for any particular network device there's always a minimum time that you can never beat. That's called the latency of the device. Retrieved from Institute for Local Self-Reliance & CloudFare*

**Lit Fiber:** is an active fiber optic cable capable of transmitting data and denotes fiber infrastructure that is being used to provide internet service. *Retrieved from NTIA & Broadband Search*.

**Middle Mile:** also referred to as Backhaul, is the connection between a local network, also called a "last mile" connection, and a "first mile" backbone internet. The section of the network that connects the last mile portion of the network to the service provider's core network, where the services such as broadband, TV, and phone service originate from. Middle mile is a term most often referring to the network connection between the last mile and greater internet. *Retrieved from NTIA & CDT*.

**Mobile Broadband:** is the name used to describe various types of wireless high-speed internet access through a portable modem, telephone or other device. Also called cellular, mobile wireless delivers connectivity by using a router or hotspot to connect to a cellular network, just like your cell phones. Speed depends on proximity to a cell tower, network congestion, and more. Mobile/cellular wireless speeds are significantly slower than fiber, cable, or fixed wireless connections. *Retrieved from European Commission & FCC*

**Municipal Network:** A broadband network owned by a local government, or municipality. These networks take many forms, from modest networks serving a few businesses to networks that are available at every address across a community. Some are run by the municipality and others are managed by an ISP under contract, called a "managed service provider" (MSP). *Retrieved from CCF*

**NTIA - National Telecommunications and Information Administration:** is an agency of the federal Department of Commerce that serves as advisor to the President on the impact of telecommunications policies on the nation's economic and technological advancement and on the telecommunications industry itself. *Retrieved from NTIA*

**Open Access Network:** Networks that are owned by one entity and available for separate service providers to sell retail services. Networks that receive public funds, or that are operated by a public or nonprofit entity, are often required to provide open access. Open Access Networks generally offer wholesale access to network infrastructure or services provided on fair and reasonable terms with some degree of transparency and nondiscrimination. These services must be supplied by separate retail service providers. Open Access Networks tend to provide more competition from which potential subscribers can choose. *Retrieved from NTIA, Community Networks, & Pew Charitable Trusts*.

**Rural and Urban Regional Broadband Consortia:** California-based regional associations that aim to accelerate broadband infrastructure deployment to the digitally disadvantaged in their communities. There are 13 consortia across the state and they are funded by California Advanced Services Fund, which is part of the California Public Utilities Commission (CPUC). Consortiums work with CPUC, internet service providers, and community stakeholders to identify project opportunities in their communities and provide technical support in submitting the necessary applications to the CPUC requesting funding to install high-speed internet infrastructure. Monterey Bay's regional consortium is the Central Coast Broadband Consortium (CCBC). *Retrieved from CCF*.

**Rights-of-Way:** Legal rights of passage over land owned by another. Carriers and service providers must obtain rights-of-way to dig trenches or plant poles for cable systems, and to place wireless antennae. *Retrieved from CPUC*.

**Rural-Urban Area Classifications:** is a delineation of geographic areas, identifying both individual urban and rural areas in a specified region.The US Census Bureau's urban areas represent densely developed territory, and encompass residential, commercial, and other non-residential urban land uses, while rural areas encompasses all population, housing, and territory not included within an urban area.

- For the 2020 Census, an urban area comprises a densely settled core of census blocks that met the minimum housing unit density (at least 2,000 housing units) and/or population density requirements (at least 5,000).

*Retrieved from U.S. Census.*

**Satellite:** is a type of wireless broadband technology that provides links for broadband and useful for serving remote or sparsely populated areas. Satellite speeds vary but tend to be slower than DSL and cable modem, but are about 10 times faster than the download speed with dial-up internet access. Satellite connections tend to be more expensive and slower than wired or fixed wireless connections and can be disrupted in extreme weather conditions. While satellite can be the only option for remote residents, it generally will not be able to serve large urban populations due to bandwidth limitations. *Retrieved from NTIA & FCC*

**SDSL (Symmetrical DSL):** is typically used by businesses for services such as video conferencing, which need significant upstream and downstream bandwidth. The transmission bandwidth for uploads and downloads is equal. Internet connections have two components - downstream and upstream. When the two speeds are comparable, the connection is termed symmetric. *Retrieved from NTIA & FCC*

**Speed:** The rate at which a device can send or receive data. Speed is defined for both download (the rate at which data is sent from the internet to a device) and upload (the rate at which data is sent from a device to the internet). Speeds are conveyed in megabits per second. *Retrieved from CPUC & CPUC-CASF*

**Subscribership**: is how many customers have subscribed for a particular telecommunications service. Any natural person or legal entity who or which is a party to a contract with the provider of publicly available electronic communications services for the supply of such services. *Retrieved from NDIA*

**Symmetrical/Asymmetrical Speeds:** Internet speeds have two components - downstream and upstream. When the two speeds are not the same, the connection is asymmetrical. When upload and download speeds are the same, the connection is symmetrical. Typically, phone and cable companies offer much slower upload speeds than download, in part because the internet tended to be a download-centric system in the '90s and early '00s. However, users increasingly need faster upstream connections to take full advantage of modern applications, like video for remote school, work, and health applications. *Retrieved from CCF*

**Take rate:** the percentage of customers within an ISP's service area who subscribe to, or "take," the service. *Retrieved from Pew Charitable Trusts.*

**Underserved Areas:** are areas that have internet access at speeds higher than those that are defined as "unserved" but lower than those that have broadband service as defined by the state or federal program. Underserved areas tend to be areas not currently served by a "wired" or "wireline" connection (versus a mobile/cellular or "fixed wireless" connection) that reliably delivers at least 25 Mbps download speed and 3 Mbps of upload speed, the FCC's minimum threshold to be considered broadband-level service. *Retrieved from CFF & Pew Charitable Trusts.*

**Underserved Areas:** are areas that have internet access at speeds higher than those that are defined as "unserved" but lower than those that have broadband service as defined by the state or federal program. Underserved areas tend to be areas not currently served by a "wired" or "wireline" connection (versus a mobile/cellular or "fixed wireless" connection) that reliably delivers at least 25 Mbps download speed and 3 Mbps of upload speed, the FCC's minimum threshold to be considered broadband-level service. *Retrieved from CFF & Pew Charitable Trusts*.

**Unserved Areas:** Areas that lack access to broadband service as defined by the state or federal program. As defined by CASF, are locations that are not currently served by a "wired" or "wireline" connection that reliably delivers at least 25 Mbps download speed and 3 Mbps of upload speed (<25/3 Mbps). *Retrieved from CPUC, CPUC-CASF, & Pew Charitable Trusts*.

**Upstream:** refers to the rate at which the user's computer can send data to the internet. Internet connections have two components - downstream and upstream. *Retrieved from CPUC & FCC*

**VLAN - Virtual Local Area Network:** A network of computers that behave as if they are connected to the same wire even though they may actually be physically located on different segments of a LAN. *Retrieved from CPUC*

**VoIP - Voice Over Internet Protocol:** is a new technology that employs a data network (such as a broadband connection) to transmit voice conversations. A technology used for transmitting standard telephone calls over the internet using packet-linked routes, from any device, including mobile and fixed line phones. *Retrieved from CPUC, NTIA & FCC*

**Wi-Fi:** is a technology that produces a wireless local area network that uses radio waves to allow computers and other devices to communicate over wireless high-speed signals. Equipment in the device communicates with the Wi-Fi router, which is connected to the network with some type of physical cable or wire. Wi-Fi has proved tremendously successful in homes and businesses in small cities. *Retrieved from CPUC & NTIA*

**Wireless:** is a type of broadband technology that connects a home or business to the internet using a radio link between the customer's location and the service provider's facility. Wireless broadband can be mobile or fixed. *Retrieved from CPUC & NTIA*

**Wireless Router:** is a wireless router connected directly to a modem by a cable. This allows it to receive information from — and transmit information to — the internet. The router then creates your home Wi-Fi network using built-in antennas. *Retrieved from Office of Educational Technology & Cisco*

**WISP - Wireless Internet Service Provider:** is an ISP that provides service through a wireless network. *Retrieved from CPUC, NTIA & FCC*.

# REFERENCES


California Department of Technology. (n.d.). State of california middle-mile broadband initiative. State of California Middle-Mile Broadband Initiative. https://middle-mile-broadband-initiative.cdt.ca.gov/

Hayes, J., Gao, N., Starr, D., Liu, A. G., & Hsieh, V. (2023, April 20). Policy brief: Achieving Universal Broadband in California. Public Policy Institute of California. https://www.ppic.org/publication/policy-brief-achieving-universal-broadband-in-california/

California Telehealth Policy Coalition. (2021, September). SB 156 fact sheet - cchpca.org. CCPHA. https://www.cchpca.org/2022/01/SB156_factsheet_0921_r3_091621-4.pdf

Witkowski, D. (2019). Bridging the Gap: 21st Century Wireless Telecommunications Handbook, Second Edition.

Witkowski, D. (2023). White Paper: An Empirical Comparison of Hotspot 2.0 Backends for Wi-Fi Offload, January 2023 Edition.

The National Telecommunications and Information Administration (NTIA). (2020, December 9). Broadband Technology Opportunities Program. Broadband Technology Opportunities Program | National Telecommunications and Information Administration. Retrieved April 19, 2023, from https://ntia.gov/category/broadband-technology-opportunities-program

ITU & UNESCO . (2022, November 8). The State of Broadband 2022. Broadband Commission. Retrieved April 19, 2023, from https://www.broadbandcommission.org/publication/state-of-broadband-2022/

Broadband Portal. OECD. (2021). Retrieved April 19, 2023, from https://www.oecd.org/sti/broadband/broadband-statistics/#:~:text=Fibre%20is%20now%20the%20dominant,fibre%20subscriptions%20of%20over%2050%25.

Pew Research Center. (2023, March 31). Internet & technology - research and data from Pew Research Center. Pew Research Center. Retrieved April 19, 2023, from https://www.pewresearch.org/topic/internet-technology/

Shaping the future of Broadband. Broadband Forum. (2023, April 19). Retrieved April 19, 2023, from https://www.broadband-forum.org/

International Journal of Advanced Research in Computer Science. (n.d.). Retrieved April 19, 2023, from http://www.ijarcs.info/index.php/Ijarcs

International Journal of Computer Science and Software Engineering. IJCSSE. (n.d.). Retrieved April 19, 2023, from http://ijcsse.org/

The National Science Foundation. (2021). Broadband Technologies. Retrieved April 19, 2023 from *https://par.nsf.gov/servlets/purl/10061643*

The State of Broadband 2021. The United Nations Broadband Commission for Sustainable Development. (2021). Broadband Technologies. Retrieved from *https://broadbandcommission.org/publication/state-of-broadband-2021/*

National Broadband Mapping. FCC. (2023). Retrieved April 19, 2023, from *https://broadbandmap.fcc.gov/home*

Affordable Connectivity Program Enrollment Tracker. California's Broadband-For-All (2023) Retrieved April 19, 2023, from *https://broadbandforall.cdt.ca.gov/*