BROADBAND
IN RURAL WISCONSIN

IDENTIFYING GAPS, HIGHLIGHTING SUCCESSES

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Executive Summary

Broadband in Rural Wisconsin

Universal broadband access is crucial for Wisconsin. Over the past two decades, the growing importance of broadband for business, farming, school, and governments has been obvious. The COVID-19 pandemic has re-emphasized its critical nature. While broadband access is nearly universal in Wisconsin cities and villages, there are major gaps in rural Wisconsin. According to the most recent data from the Federal Communications Commission, 25% of rural residents lack access to 25 Mbps broadband, the speed which is now considered the standard. Wisconsin's level of inaccessibility is worse than the national average and 35 other states.

Rural access to 25 Mbps broadband varies widely by county. The highest levels of access generally are in the relatively small rural parts of urban counties, such as Kenosha, Racine, and Waukesha counties. However, in nine more sparsely-populated counties—Ashland, Clark, Douglas, Iron, Marinette, Price, Richland, Rusk, and Taylor—less than half of the rural population has broadband at that speed available.

Wisconsin's broadband infrastructure does have key successes, though. Access levels at speeds of 10 Mbps or higher are better than the U.S. average—93.6% of rural Wisconsin residents had access to those speeds vs. 91.3% nationally. In areas with 10 Mbps access, the strategy for achieving universal 25 Mbps access will involve upgrading current service rather than bringing new broadband to areas where it does not exist.

The state has also shown how a variety of technologies and strategies can be employed to provide broadband to rural populations. In Vernon, Ozaukee, Kewaunee, and Pierce counties, at least 92% of the rural population has access to 25 Mbps broadband. In Vernon County, fiber is by far the primary technology for accessing it. In Ozaukee, nearly 90% gain access through cable or DSL lines. Eighty percent of Kewaunee County residents receive broadband via fixed wireless towers. Pierce County has no dominant technology; a combination of these technologies are employed for a high level of broadband access.

Local governments can play a leadership role in solving the problem of adequate universal broadband. They are uniquely positioned to identify underserved areas, which is a critical first step in addressing the access issue. Additionally, local governments can help connect local private providers to various state or federal grant programs, as successful broadband projects often require the collaboration of multiple stakeholders to identify and address the problem.

Broadband in Rural Wisconsin

Identifying Gaps, Highlighting Successes

Dale Knapp, Director and Jack Votava, Researcher

The COVID-19 pandemic has re-emphasized the critical importance of broadband infrastructure in both Wisconsin and nationally. Businesses, schools, and households rely on fast, reliable internet for day-to-day operations. The pandemic has made telecommuting, virtual meetings, and online education commonplace, placing greater demands on broadband infrastructure.

Access to broadband will only continue to grow in importance in the years ahead. Nationwide, nearly 75% of businesses recently reported that reliable internet was crucial to productivity.

In Wisconsin and around the country, many individuals and families continue to face obstacles to accessing adequate internet service. In urban areas, high residential density encourages multiple providers to offer broadband services. Access problems in these areas usually stem from a combination of poverty and broadband costs.

In contrast, low residential density in rural areas makes it costly for providers to offer service, leaving many rural residents without access to broadband. For instance, of Wisconsin school districts that served fewer than 500 students, nearly half reported significant problems with students accessing the internet at home (at least 25% of students had no broadband in the home). The adverse effects of these access issues will grow as education, business, and government services increasingly rely on the internet.

Local governments can play a leadership role in solving the problem of adequate universal broadband. They are uniquely positioned to identify underserved areas, which is a critical first step in addressing the access issue. Additionally, local governments can help connect local private providers to various state or federal grant programs, as successful broadband projects often require the collaboration of multiple stakeholders to identify and address the problem.

BROADBAND BASICS

Broadband is the term used to describe a high-speed connection to the internet. It is called broadband because the bandwidth used is wide, allowing multiple signals at once, as opposed to the dated single-line, dial-up technology. Broadband can use different methods of connection, but most commonly include fiber-optic lines or copper cabling.

Broadband service generally consists of three stages—the backbone, the middle mile, and the last mile. The backbone is the series of strategically connected computer networks that direct internet traffic on the best available path to its destination. The middle mile is a physical network of thick bundles of underground fiber-optic or copper cables, or wireless towers that link communities, or more specifically, the internet service providers (ISP) in each community, to the internet backbone. The last mile is the network that connects individual households, businesses, and schools to the middle mile. For example, it is the cable that runs from a home to the ISP.

The focus of this report is on last-mile access in rural areas of Wisconsin.

Delivering Last-Mile Access

Several technologies deliver last-mile service. Most households have a wired connection, consisting of either a fiber-optic cable or a copper cable, to their ISP.

Other households use a special antenna to access nearby network towers that use radio waves to connect to the internet. This last-mile technology is called a fixed wireless connection.

Those without access to either wired or fixed wireless connections can use satellite technology to gain access to the internet. This is generally a more expensive and less reliable option and therefore is not widely used.

Access Speeds

Households use the internet for a variety of purposes, some requiring higher speeds than others. The Federal Communications Commission (FCC) defines broadband internet as any of the high-speed technologies—fiber, cable, fixed wireless, or satellite. Regardless of technology, broadband internet access is defined by three traits: download speed, upload speed, and latency (or lag time).

Download speed is the rate at which data is transferred from the internet to the user's computer. Most users need high download speeds to access documents, movies, songs, etc. in a reasonable time. Table 1 summarizes the ability to perform various internet tasks at different download speeds. These speeds are what internet service providers advertise as the maximum possible download speed for a particular plan they sell. For example, a 10 megabytes per second (Mbps) internet plan will deliver at most a 10 Mbps download speed and may, due to a variety of factors, deliver substantially less than that at any given time.

Upload speed is the rate that data is transferred from the user's computer to the internet. Upload speeds are generally lower than download speeds. They are often overlooked but are crucial for sending, uploading, or modifying files on the internet, or for conducting virtual meetings, which have recently become so important.

Another often-overlooked component of internet access is latency, or "lag," which is defined as the delay between a user's action and a web application's response to that action. High-latency connections often seem slow, since every new page or internet function accessed will lag behind the request.

Users can have high download speeds, while having high latency or slow upload speeds. It is for this reason that certain technologies, such as satellite internet, have competitive download speeds but, because of slow upload speeds or high latency, are not suitable for video conferences or real-time internet communication.

Speed & Technology

In many cases, download and upload speeds are closely tied to the technology used to access the internet. Wired connections generally are able to provide higher speeds than wireless connections.

Fiber. The fastest and most "future-proof" technology available is fiber-optic cable. Fiber cables can handle nearly any transmission speed, allowing households to be internet secure even in the long term.

Unfortunately, fiber-optic cables are the most expensive last-mile option, with construction costs usually ranging between $60,000 and $100,000 per mile. While maintenance costs are manageable, raising sufficient initial capital to fund new construction is often insurmountable for many rural areas. For this reason, only about 15% of current rural Wisconsin residents have access to fiber internet options. The state of Wisconsin ranked 40th on the percentage of residents using fiber to access the internet.

Cable/DSL. For households without fiber options, wired technologies are an alternative. These technologies include: (1) cable connections, where the internet data is sent using cable TV wires; and (2) DSL connections that transmit internet data over

Table 1: Broadband Speed and Tasks

Internet Capabilities by Number of Devices and Download Speed (Source: FCC)

Download Speed	Possible Uses		
	1 Device	2 Devices	3 Devices
0.2 - 4 Mbps	Basic	Minimal	-
4 - 10 Mbps	Moderate	Basic	Minimal
10 - 25 Mbps	Advanced	Moderate	Basic
25+ Mbps	Advanced	Advanced	Moderate

Minimal: E-mail, text-based browsing
Basic: Minimal plus most browsing, low quality pre-recorded video and audio
Moderate: Basic plus streaming video, live video, gaming
Advanced: Moderate plus multiple high-demand applications simultaneously, large downloads

phone lines. These technologies can be useful for filling the need to provide broadband but suffer from drawbacks.

Cable internet has the same cost issues as fiber, but connection speeds are not as reliable or as future-proof. DSL takes advantage of near-omnipresent phone lines but have relatively low reliability and suffer decreasing speeds the farther the household is from the middle-mile infrastructure.

In Wisconsin, 75% of rural residents have access to some form of cable or DSL internet service instead of fiber; however, only two-thirds of them have access to 25 Mbps or higher service.

Fixed Wireless. In areas where population density or terrain mean that wired options are not economically viable, wireless options can help fill the gap. The key wireless technology in Wisconsin is fixed wireless internet—a household sets up an antenna on premises and receives an internet connection from the closest cell tower or specially-constructed wireless tower.

Fixed wireless has the advantage of carrying a signal across hilly or forested areas that are difficult to access with cable. This technology also takes advantage of existing cellular networks that provide WiFi. In areas without sufficient cell towers, signal towers can be constructed for a comparatively low cost.

A drawback of fixed wireless towers is that they are not the most reliable or future-proof internet connection technology because they suffer from latency constraints, limited speed options, and weather effects.

Wisconsin's use of fixed wireless towers to fill in the gap in wired connections is among the highest in the nation. At any speed, fixed wireless technology fills over 90% of the wired gap, the 6th highest percentage in the nation. However, it has been less effective at filling the gap at high speeds. At 25 Mbps or greater, fixed wireless fills only 30% of the wired gap.

Satellite. In the most remote areas of Wisconsin, satellite internet continues to be the only option. Satellite internet refers to the connection between households and geosynchronous satellites orbiting the Earth. Satellite technology allows for internet connectivity from nearly anywhere on the globe.

Satellite internet plans tend to have price and latency issues. A 25 Mbps satellite internet plan in Wisconsin, for instance, typically costs households at least $150/month, not including antenna equipment. Comparable wired or fixed wireless plans are much less costly and more reliable. Furthermore, latency issues prevent satellite internet from being effective for calls or video conferences. Thus, satellite internet is usually a last resort for households.

In the future, satellite internet may become a more viable alternative as companies compete to put Low-Earth Orbit (LEO) systems online. A grid of LEO satellites has shown promise in providing high-speed internet with significantly reduced latency problems to nearly any location on Earth. However, it is not clear if this technology is economically viable for providers, affordable for consumers, and truly adequate in service.

RURAL ACCESS BY COUNTY

In general, Wisconsin has some successes in its broadband infrastructure compared to other states but faces challenges in other areas.

As of 2019, the most recent year for which data are available, the FCC reports that 99.1% of rural Wisconsin residents had access to a non-satellite internet option of at least 0.2 Mbps. This exceeded the national average of 95.4% of rural residents with access. However, as Table 1 showed, speeds under 10 Mbps are generally inadequate for most uses. At speeds of at least 10 Mbps, Wisconsin still had an advantage with rural coverage of 93.6% of residents compared to 91.3% nationally (see Figure 1 on page 6).

When considering internet options that offer speeds of at least 25 Mbps—what is now considered standard for reliable broadband access—Wisconsin lagged. Only 74.9% of rural Wisconsin residents had at least one provider that offered such service, significantly less than the national average of 80.1%. This left more than 430,000 rural Wisconsin residents without 25 Mbps broadband access in 2019. The state ranked 36th nationally on this measure of rural broadband access.

In other words, while gaps need to be filled, the state is in a relatively good position at speeds of 10 Mbps or more. However, what we really need to know is the actual speeds consumers are getting. If the advertised maximum speed is 10

Mbps, consumers are likely experiencing lower speeds some of the time.

As the internet is vital to education, business, and farming, increasing access to speeds of 25 Mbps or more is critical for a robust, growing economy. Wisconsin has considerably more work to do in this area.

There is an important caveat to the population percentages reported above and throughout the remainder of this report. The reported percentages of residents with access to a certain download speed can overstate the actual percentage. The FCC reports access at the U.S. Census block level, the smallest geographic unit used by the bureau. If any household in a block has broadband access, the FCC treats the entire block as having access.

In a city, a census block is typically an actual city block. Thus, when one person in the block has access, more than likely all households in that block have access. However, in rural areas, a census block can be many square miles. In these areas, it can be the case that only a fraction of households have access to broadband, even though the FCC data indicates that all have access.

County Access by Population

Within Wisconsin, rural access to broadband is not uniform. Figure 2 on page 7 summarizes rural access by county at speeds of 10 Mbps or greater (left) and 25 Mbps or greater (right).

The relative success of Wisconsin at the 10 Mbps level is clear in Figure 2. In 29 of the state's 72 counties, fewer than 500 rural residents lacked access to speeds of at least 10 Mbps (dark teal in left map on page 7). In another eight counties, the number of residents without access was less than 1,000.

By contrast, at speeds of 25 Mbps or greater, the number of residents lacking access exceeded 10,000 in 15 counties (dark orange in right map). In another 24, more than 5,000 rural Wisconsinites lacked access.

County Access by Percentages

A second way to look at broadband availability is the percentage of the rural population in each county with access at various speeds. In nine counties–Ashland, Clark, Douglas, Iron, Marinette, Price, Richland, Rusk, and Taylor–less than half of the rural population had access to broadband speeds of 25 Mbps or more (see Table 2, page 9). In another eight counties, less than 60% had such access.

Those percentages tell a grim story about the availability of "adequate" broadband access in Wisconsin. However, they do not tell the whole story on the availability of broadband.

For example, Ashland and Douglas counties have 25 Mbps broadband available to similar shares of their rural populations—49.4% and 48.8%, respectively. But, according to the FCC data, nearly

Figure 1: Rural Broadband Access

% of Rural Population at Various Speeds in Mbps, Wisconsin vs. U.S., 2019

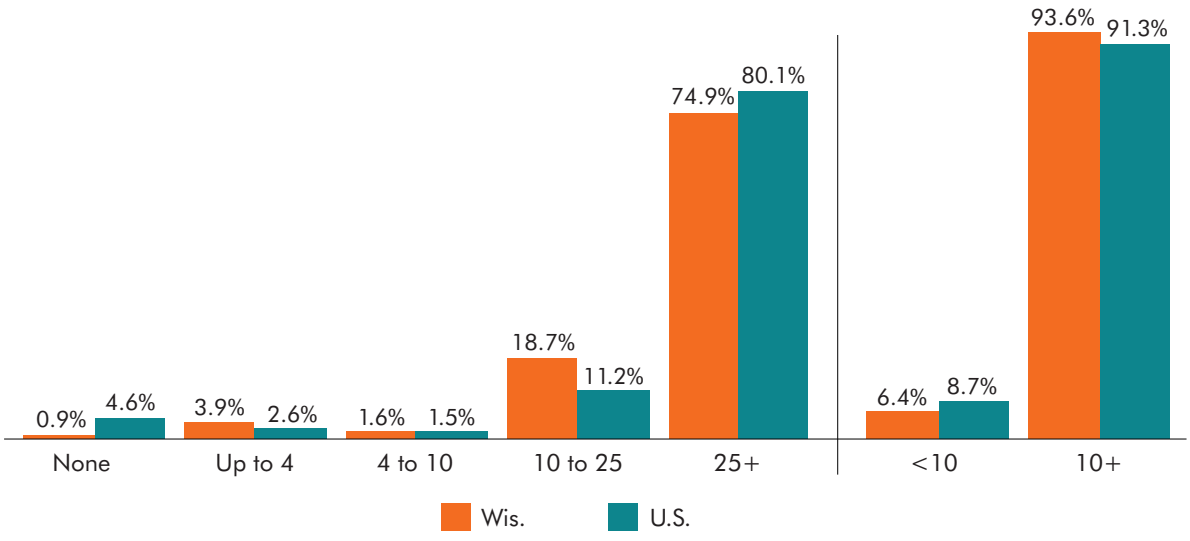
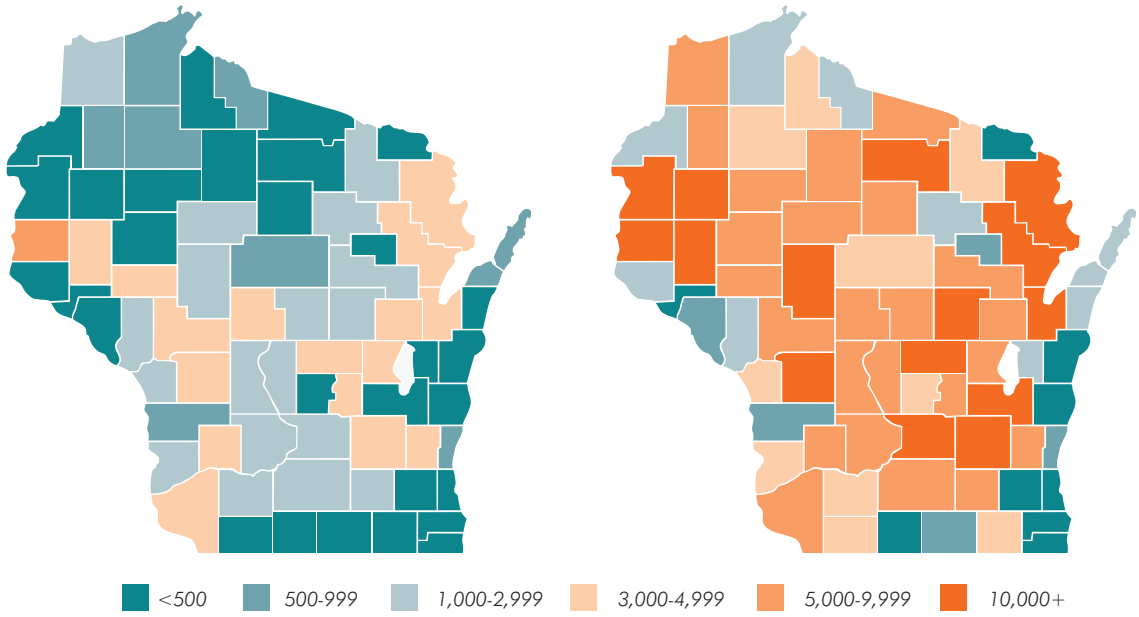


Figure 2: Rural Access by County

Number of Wisconsin Residents Without Access to 10 Mbps (left) and 25 Mbps (right) Broadband, 2019



everyone in Ashland County without availability at this speed has access to at least 10 Mbps. In Douglas County, 15% of rural residents only have broadband speeds of less than 10 Mbps available and 3% have no access.

Ranking Access

To simplify the figures in Table 3, Forward Analytics analysts constructed an algorithm to create a score that takes into account access across the entire range of broadband speeds. Possible scores range from zero (no broadband access in the rural parts of the county at any speed) to 100 (all rural residents had access to 25 Mbps broadband). For context, when states are ranked using this algorithm, Wisconsin's score of 88.9 ranked 26th nationally. While the actual score is not shown, the last column in Table 2 shows each county's rank on the measure.

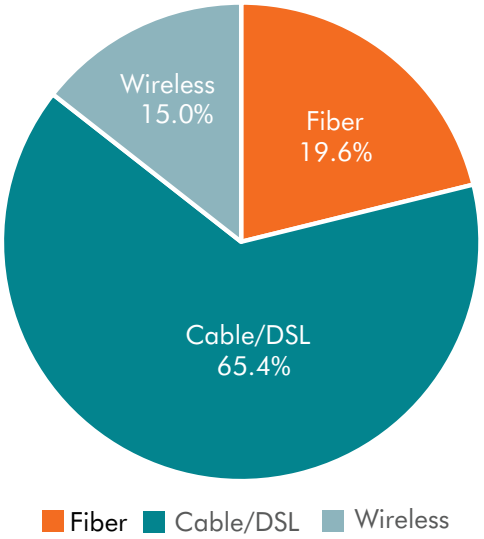
A quarter of Wisconsin counties scored 95 or higher. While there are a variety of ways to achieve that score, two criteria are necessary: at least 84% of rural residents have access to 25 Mbps broadband, and no more than 7% have less than 10 Mbps.

The top 10 counties in Wisconsin tended to be urban, with populous Racine, Milwaukee, Waukesha, and Kenosha on the list. Pepin and Green counties are much less populous but had very good broadband coverage.

Trailing only Dunn and Eau Claire counties, Richland County had the third-highest percentage of its rural population with no internet access. However, the major difference between these three counties is that in Dunn and Eau Claire counties, more than 60% of rural residents had access to broadband speeds of 25 Mbps or more. In Richland County, only 35% had those speeds available. Based on this measure, Richland County is the county most in need of greater access to broadband for rural residents and service upgrades to higher speeds for those with broadband currently. Others faring poorly on this measure were Jackson, Marinette, Douglas, and Forest counties.

With few exceptions, Table 2 shows that most counties have some rural broadband need. For some counties, the priority might be to urgently address the populations who lack non-satellite internet access entirely. For others, it might be upgrading areas with less than 10 Mbps internet to the higher 25 Mbps. While the ultimate gold standard is universal fiber cable, many areas may have to be flexible about the ways they address short-term needs while continuing to build a more future-proof fiber expansion.

Figure 3: Access Technology Varies
25 Mbps Broadband Availability by Technology



DIFFERENT STRATEGIES FOR SUCCESS

Over 70% of Wisconsin rural residents had access to 25 Mbps broadband from either fiber, cable, or fixed wireless. However, only one in five residents has access to broadband via the best technology—fiber (see Figure 3). Nearly two-thirds of Wisconsinites use cable or DSL to access 25 Mbps broadband, while less than 15% use fixed wireless.

However, combinations of these technologies may be deployed as part of a comprehensive strategy to address a specific area's short- and long-term broadband access needs. The experiences of Vernon, Ozaukee, Kewaunee, and Pierce counties are illustrative. In these counties, at least 92% of rural residents had access to 25 Mbps broadband.

In Vernon County, the dominant technology is fiber, with 77% of those with 25 Mbps access having it available (see Figure 4). Access in Ozaukee County is primarily through cable or DSL connections (87% of those with access). Only 7% of rural Ozaukee County have fiber connections available. Kewaunee County is unusual in that fixed wireless is the dominant technology for accessing high-speed internet (80% of those with access). All other rural residents use cable or DSL connections. In Pierce County, a more even combination of the technologies is employed, with 40% accessing through fixed wireless, 39% via cable or DSL, and 21% through fiber.

CONCLUSION

The broadband landscape in Wisconsin is rapidly changing for both service providers and consumers. As access to the internet becomes more crucial than ever to the success of rural areas, state and local governments are helping service providers assess and sometimes fund a variety of access expansion options.

Fueled by state and federal grants, the most favorable option is an expansion of fiber-optic last mile internet service, as these connections offer the ability to meet speed and reliability needs both now and into the foreseeable future. However, the high construction cost of fiber cable means that many areas will have to look towards supplementary non-fiber wired options, fixed wireless towers, or satellite internet.

Plans for broadband expansion should balance cost, the long-term considerations of a technology's ability to provide adequate speed and reliability, and the short-term urgency to expand internet access to all state residents. The ideal mix of options will likely look different for every area. In particular, Wisconsin's reliance on fixed wireless towers provides an effective means for many rural areas to get by for now, but it is not future-proof for long-term needs. Those looking to expand fiber availability should consider cost and set realistic targets for what areas may be feasible to set up new service options.

Figure 4: Alternative Formulas To Access
Access Type in Four Counties With 92% to 96% Access to 25 Mbps Broadband

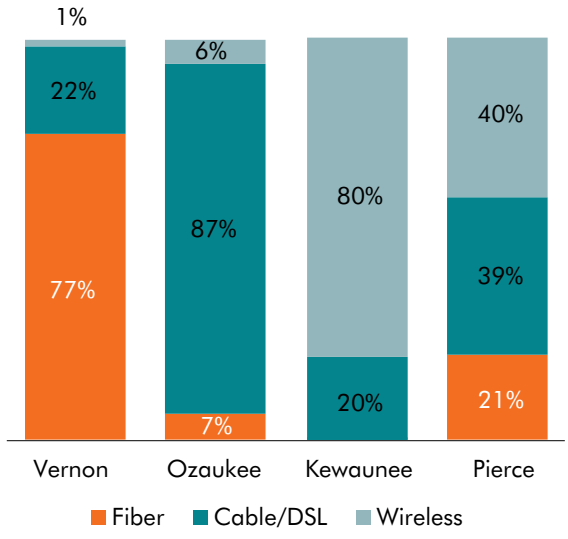


Table 2: Rural Broadband Access Detail

% of Rural Population With Broadband Access at Various Speeds in Mbps, By County, 2019

County	25+	10-24	<10	None	Rk.*	County	25+	10-24	<10	None	Rk.*
Adams	67.7%	25.9%	6.4%	0.0%	39	Marathon	94.4%	4.6%	1.0%	0.0%	10
Ashland	49.4%	50.5%	0.0%	0.1%	47	Marinette	41.6%	42.7%	15.7%	0.0%	70
Barron	62.4%	37.3%	0.2%	0.1%	35	Marquette	74.3%	23.5%	1.6%	0.6%	25
Bayfield	86.3%	8.0%	5.0%	0.8%	23	Menominee	52.9%	34.2%	12.8%	0.1%	62
Brown	72.4%	18.4%	9.2%	0.0%	43	Milwaukee	99.9%	0.0%	0.1%	0.0%	3
Buffalo	95.6%	0.9%	3.5%	0.0%	14	Monroe	62.3%	24.5%	12.9%	0.3%	57
Burnett	86.2%	11.8%	1.7%	0.3%	19	Oconto	54.4%	34.6%	11.0%	0.0%	60
Calumet	87.9%	11.9%	0.2%	0.0%	17	Oneida	61.0%	38.1%	0.9%	0.1%	38
Chippewa	68.5%	31.2%	0.3%	0.1%	27	Outagamie	77.4%	14.1%	8.5%	0.0%	37
Clark	49.1%	42.6%	8.2%	0.1%	55	Ozaukee	95.9%	1.7%	2.2%	0.2%	13
Columbia	57.7%	37.1%	4.3%	0.8%	49	Pepin	97.3%	1.6%	0.8%	0.3%	9
Crawford	63.7%	20.8%	15.0%	0.5%	59	Pierce	94.5%	3.9%	1.4%	0.2%	12
Dane	91.0%	6.3%	1.8%	0.9%	18	Polk	68.0%	30.9%	0.8%	0.3%	30
Dodge	56.5%	36.5%	5.0%	2.0%	53	Portage	73.7%	20.0%	6.3%	0.0%	32
Door	85.9%	11.2%	2.8%	0.0%	20	Price	47.7%	51.9%	0.3%	0.1%	51
Douglas	48.8%	33.4%	14.7%	3.1%	69	Racine	100.0%	0.0%	0.0%	0.0%	1
Dunn	61.5%	23.4%	6.7%	8.4%	64	Richland	35.1%	35.3%	24.8%	4.9%	72
Eau Claire	66.8%	19.2%	6.6%	7.4%	56	Rock	98.3%	1.2%	0.3%	0.2%	8
Florence	90.7%	3.0%	4.5%	1.8%	22	Rusk	35.5%	63.8%	0.5%	0.2%	58
Fond Du Lac	64.0%	35.9%	0.1%	0.0%	34	Sauk	68.6%	24.2%	7.2%	0.0%	40
Forest	54.6%	27.4%	16.9%	1.1%	68	Sawyer	62.4%	30.6%	4.8%	2.2%	48
Grant	79.1%	6.2%	13.7%	1.0%	46	Shawano	76.2%	18.6%	5.3%	0.0%	29
Green	99.6%	0.4%	0.0%	0.0%	5	Sheboygan	99.9%	0.0%	0.1%	0.0%	2
Green Lake	58.3%	18.5%	20.3%	2.9%	67	St. Croix	65.0%	23.8%	6.9%	4.2%	52
Iowa	84.2%	6.6%	8.3%	0.8%	31	Taylor	45.0%	44.0%	10.6%	0.3%	63
Iron	47.8%	39.0%	11.4%	1.7%	66	Trempealeau	91.6%	2.7%	5.6%	0.1%	21
Jackson	52.8%	22.2%	24.9%	0.1%	71	Vernon	96.4%	1.2%	2.2%	0.2%	11
Jefferson	72.0%	19.7%	6.3%	2.0%	42	Vilas	69.9%	28.6%	0.4%	1.1%	28
Juneau	66.8%	23.2%	7.8%	2.2%	50	Walworth	88.6%	11.3%	0.2%	0.0%	16
Kenosha	98.9%	0.5%	0.5%	0.0%	7	Washburn	61.2%	34.8%	2.7%	1.2%	45
Kewaunee	92.8%	5.2%	2.1%	0.0%	15	Washington	87.4%	4.5%	3.6%	4.5%	26
La Crosse	81.3%	6.1%	12.4%	0.3%	41	Waukesha	99.6%	0.2%	0.1%	0.0%	6
Lafayette	71.1%	28.9%	0.0%	0.0%	24	Waupaca	69.6%	25.2%	5.2%	0.1%	36
Langlade	74.9%	13.9%	11.2%	0.0%	44	Waushara	52.6%	27.4%	20.0%	0.0%	65
Lincoln	64.8%	35.2%	0.1%	0.0%	33	Winnebago	69.2%	12.0%	18.7%	0.2%	61
Manitowoc	99.8%	0.1%	0.1%	0.0%	4	Wood	63.5%	20.8%	15.7%	0.0%	54

**Rank based on weighted average of population percentages at various download speeds, with higher speeds given higher weights.*

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