Michigan's Path to a Prosperous Future: Infrastructure Challenges and Opportunities

Paper 4b in a Five-Part Series

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About the Series

Altarum and the Citizens Research Council of Michigan have joined forces to present a realistic, data-informed vision of Michigan's future based on current trends and trajectories across multiple dimensions – economic, demographic, workforce, infrastructure, environment, and public services. The papers are available on both organizations' websites.

Research for this project was conducted in two phases. Phase I involved a landscape scan of existing resources and expert knowledge of trends and challenges. For each domain, published and grey literature were reviewed and interviews with stakeholders were conducted to answer questions such as:

- Where is Michigan now – strengths, weaknesses, major challenges?
- What data is available to characterize the current situation and to track progress? Are there existing forecasts, either descriptive or data-driven?
- How does Michigan compare to other states, especially in the Midwest?
- What path are we on currently, and where are opportunities to shift the path through policies and investment?

Phase 2, as represented in an Executive Summary and a series of five papers, built on Phase 1 to include data and context.

Altarum (altarum.org) is a nonprofit organization focused on improving the health of individuals with fewer financial resources and populations disenfranchised by the health care system.

The Citizens Research Council (crcmich.org) works to improve government in Michigan by providing factual, unbiased, independent information concerning significant issues of state and local government organization, policy, and finance.

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Report Highlights

- Many of Michigan's infrastructure funding problems relate to the state's embrace of suburban 'sprawl' style development in an era of marginal population growth. As cities depopulated and suburbs expanded, Michigan residents are now responsible for more infrastructure per person than in previous decades.
- Estimations of Michigan's transportation 'revenue gap' are substantial with no clear solutions. Michigan's approach to transportation funding and asset management deserves a full, independent review.
- The condition of Michigan's water infrastructure is generally accepted to be poor, but is largely unknown. Water infrastructure is underground, and much of it was installed before digital record keeping, making condition assessment costly and difficult.
- It will be a substantial challenge to transition to a modern, renewables-based power grid while maintaining affordability and improving reliability.
- Michigan is relatively well-served by various broadband services, but challenges remain with affordability, reliability, and equity.
- New technologies and approaches provide opportunities to better and more coherently manage Michigan's infrastructure systems for broad public benefit.
- Many of the challenges in maintaining Michigan's infrastructure in good repair are the result of decades of uncoordinated policies emphasizing short-term goals. Assuring fiscally sustainable infrastructure systems across the state will require decades of concerned effort and long-term strategic planning.

Introduction

Michigan's infrastructure is perceived to be in a crisis. Recent occurrences in Michigan have highlighted the poor state of infrastructure including perpetually potholed roads, disruptive power outages, catastrophic dam collapses, and frequent flooding.

Efforts to attract people from other states and other nations to Michigan must consider the physical environment they will find when they arrive. Much of the U.S. struggles to maintain infrastructure in good repair, but Michigan has unique challenges and generally underperforms peer states. Understanding the current condition and challenges of Michigan's infrastructure helps to make the state attractive to prospective residents, interacts with the natural environment around it, and prepares the state for the negative consequences of climate change.

Michigan experienced rapid population growth in the early to mid-20th century, and much of the public works and infrastructure were first laid down nearly 100 years ago. In recent decades, the population of many cities and urban areas has stayed flat or decreased while surrounding suburbs and exurbs have become populated and built out. Residential density is empirically linked to monetary expenditures on infrastructure.

In 2003, then Governor Granholm created the Michigan Land Use Leadership Council, acknowledging: "The unplanned, uncontrolled consumption of open space not only impairs the quality of Michigan's land, water, and ecosystems, but will also threaten Michigan's social and economic well-being. … State-initiated land use coordination efforts will result in cost savings; better prioritization of limited state resources spent on public infrastructure, and an expansion in private economic development activities."[1]

The resulting report from the Michigan Land Use Leadership Council found that, "the state of Michigan develops its land eight times faster than its population grows." This was not an accident. "Government policies … have directly or indirectly encouraged sprawl. In Michigan, sprawling growth has had a negative effect on large urban core areas, older suburban areas, and the downtown areas of many medium sized and small towns. It has resulted in disinvestment in central cities, a decrease in tax base, and an increase in the costs of basic services."[2]

The situation with Michigan's sprawling development and declining urban areas is not unique. Many historical cities in Michigan's peer states have lost significant population since the 1950s and 1960s, while surrounding metropolitan areas expanded outwards. These cities all have aging infrastructures that need to be replaced and no longer match population patterns. There are blocks of legacy industrial cities where the road, water, sewer, power, and gas infrastructure that once served dozens of occupied homes now serves only a few.

As challenging as this is, the outer suburbs are in a worse situation in the long-term. Many newer suburban municipalities have intentionally been built-out in a low-density land use pattern, and thus each individual taxpayer and rate payer must support multiple times the value of infrastructure that delivers services.[3]

For example, a typical block in Hamtramck runs about 1,000 feet and holds about 60 homes, meaning each residence is served by about 17 feet of linear infrastructure (road and utilities). A two-block stretch of W. Allegan Street in Lansing runs about 1,500 feet and serves about 50 homes, meaning each household is responsible for about 30 feet of infrastructure. For residential developments built after around 1970 or so, it is common for each home to require 40-50 feet of infrastructure.

In other words, ratepayers in newer developments can be responsible for three to four times as much infrastructure as their pre-1950s counterparts. This math includes only the network service lines; including distribution lines in the calculation would show further discrepancy.

As a result of depopulated cities and sprawling suburban areas, many of Michigan's infrastructure networks are now structurally insolvent. Spreading system costs across a region does not solve the problem if the aggregate of taxpayers and rate payers does not have the capacity to support the cost of service. In fact, because remain-

[1] Executive Order No. 2003-4.
[2] Michigan Land Use Leadership Council. "Michigan's Land, Michigan's Future." August 15, 2003.
[3] Dustin Shane. "Stop Subsidizing Suburban Development, Charge It What It Costs." StrongTowns. July 6, 2023.

ing density in legacy cities remains higher than the suburbs, it is often low-income neighborhoods that subsidize regional and statewide services.[4,5]

There have been focused efforts in recent years to better understand and address Michigan's infrastructure problems. Estimates of Michigan's infrastructure 'funding gap' are a moving target, and subject to a plethora of necessary assumptions, but are generally in excess of $5 billion annually—sometimes *much* in excess.

Future funding is unlikely to be anywhere near this $5 billion per year gap. If estimates of the revenue gap are accurate, this implies that past infrastructure planning and investments have made the entire state structurally insolvent. Michigan must find ways to prioritize and make strategic investments to bring critical infrastructure into good repair while reducing the future maintenance and operating liabilities.

With recent federal infrastructure funding increases, Michigan has a unique opportunity to create lasting positive change. It is critical that this surge in infrastructure spending not be applied to the same types of investments that created such a structurally underfunded system.[6] Investment strategies must address the root of the problem rather than attempt to treat the symptoms.

This paper provides an overview about what is known of Michigan's infrastructure and how public policies may be revised to achieve fiscal sustainability and improve the lives of Michigan's citizens.[7]

Transportation (Roadway Pavement)

Michigan's transportation infrastructure includes roads, bridges, railways, airports, waterways, pedestrian and bicycle facilities, transit systems, and a variety of supporting infrastructure. All of these topics deserve critical analysis of existing and potential policies. For reasons of resource constraints and current priorities, this paper primarily focuses on roadway pavement.

The Michigan Department of Transportation (MDOT) is responsible for Michigan's nearly 10,000-mile state highway system, comprised of all M, I, and US-routes. It is the backbone of Michigan's 120,000-mile highway, road and street network. In addition to MDOT, there are 614 county and local agencies that own public roads in Michigan.

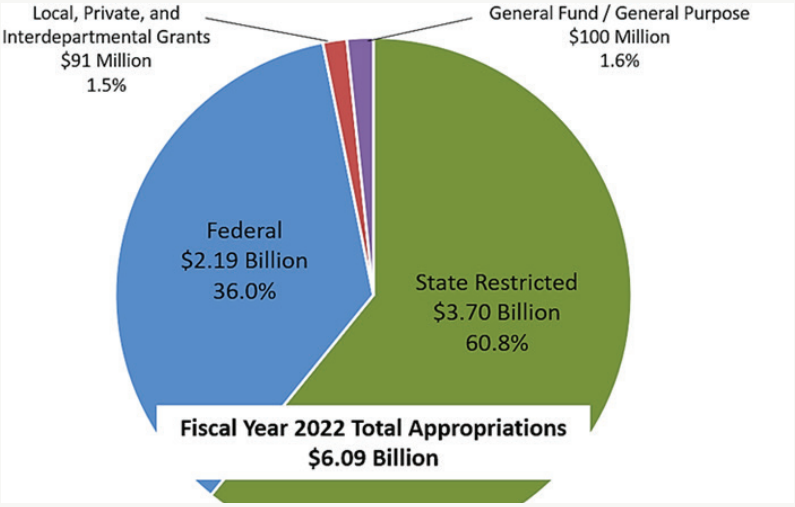
Road funding comes from multiple federal, state, and local sources. State restricted revenue, sourced mostly from fuel taxes and vehicle registration fees, accounted for about 60.8 percent of transportation funding in 2022 (**Figure 1**). This revenue is allocated by MDOT, who keeps 39.1 percent, allocates 39.1 percent to counties, and 21.8 percent to cities (after various statutory deductions).[8]

In 2022, 36 percent of transportation funding was provided by the Federal-aid Highway Program. These funds are typically distributed directly to the owners of designated Federal-aid highways, including MDOT, counties, and municipalities. Local agencies may also exchange their federal aid funding to MDOT for a 90% equivalent of state dollars.[9]This program allows local road agencies to pursue projects without compliance to federal regulations such as competitive bidding, Davis-Bacon Act wage minimums for labor, and related reporting requirements.[10]

Michigan is somewhat unique among states in that the state transportation department (MDOT) has jurisdiction of only 7.9 percent of road milage within the state. Michigan ranks 47 for percentage of the statewide road network under state jurisdiction. State-owned highways typically include the most heavily traveled routes in each state.[11] While MDOT controls only 7.9 percent of roadway milage, 51.6 percent of all vehicle miles traveled (VMT) occur on state roads. Michigan ranks 44th among states in this category (**Table 1**).

[4] Daniel Herriges. "Value Per Acre Analysis: A How-To for Beginners." StrongTowns. October 19, 2018.
[5] Notably, many western and sunbelt states have aggressively adopted sprawl style development in recent decades without realizing infrastructure funding deficits on the scale of Michigan. This is because that the overall population in these states has grown as infrastructure has expanded. Most of these areas have not yet witnessed the full life-cycle costs of their infrastructure in a period of stagnant growth. Once these regions stop growing in population, they will likely experience infrastructure funding issues more severe than Michigan's current situation. (Charles Marohn. "America's Growth Ponzi Scheme." StrongTowns. May 18, 2020.)
[6] Glaeser and Poerba. "Economic Perspectives on Infrastructure Investment." Washington D.C.: Aspen Institute Press. 2021.
[7] This paper builds on the framework introduced by the 21st Century Infrastructure Commission Report (2016).
[8] Act 51 of 1951.
[9] MDOT. Federal Aid Buyout Program. Guidelines for FY 2022.
[10] Senate Fiscal Agency. Bill Analysis: PA 49 and 50 of 2022. December 20, 2022.
[11] However, there are significant exceptions to this, especially in states where major highways are owned by a tolling authority.

Figure 1: Michigan Transportation Revenue Sources, FY2022



Source: House Fiscal Agency

Table 1: State Ownership of Public Roads and Corresponding Average Daily Vehicle Mile Traveled by State (2019 Data)

Rank	State	Public Road Milage State Ownership
1	West Virginia	88.5%
2	Delaware	83.8%
3	Virginia	78.4%
4	North Carolina	74.3%
5	South Carolina	52.1%
6	Maine	36.5%
7	***Kentucky***	***34.6%***
8	***Pennsylvania***	***32.9%***
9	Alaska	31.9%
10	Louisiana	26.8%
11	***Missouri***	***25.5%***
22	***Ohio***	***15.7%***
24	***Tennessee***	***14.6%***
Median State		**14.0%**
29	***Indiana***	***11.4%***
32	***Illinois***	***10.9%***
36	***Wisconsin***	***10.1%***
41	Idaho	9.3%
42	Washington	8.7%
43	California	8.6%
44	North Dakota	8.4%
45	***Minnesota***	***8.2%***
46	Massachusetts	8.1%
47	***MICHIGAN***	***7.9%***
48	***Iowa***	***7.8%***
49	Kansas	7.3%
50	New Jersey	6.0%

Rank	State	VMT on State-owned Roads
1	South Carolina	87.3%
2	Delaware	82.0%
3	West Virginia	81.8%
4	***Kentucky***	***79.2%***
5	Rhode Island	77.2%
6	Connecticut	75.9%
7	North Carolina	74.4%
8	Louisiana	74.0%
9	Virginia	72.3%
10	Arkansas	71.6%
12	***Pennsylvania***	***71.4%***
16	***Tennessee***	***67.5%***
23	***Missouri***	***62.9%***
25	***Iowa***	***62.3%***
Median State		**61.6%**
29	***Ohio***	***59.9%***
35	***Minnesota***	***57.2%***
38	***Wisconsin***	***55.8%***
41	***Illinois***	***54.5%***
42	Alabama	54.1%
43	Kansas	53.5%
44	***MICHIGAN***	***51.6%***
45	Massachusetts	51.2%
46	Nevada	49.0%
47	New York	48.4%
48	Arizona	46.4%
49	***Indiana***	***46.0%***
50	New Jersey	39.8%

Source: FHWA Highway Statistics 2020

System Conditions

It is well known that many of Michigan's roads are in poor condition. It is not just our perception. When Michigan's pavement conditions are rated against other states using comparable metrics, Michigan is usually in the bottom ten.[12] For example, on National Highway System (NHS) routes, 7.6 percent of Michigan's pavement was assessed to be in 'poor' condition in 2019 using a standard federal metric.[13] This is fourth worst in the nation, behind only Rhode Island,[14] Louisiana, and New Jersey (**Table 2**).[15]

Table 2: States Ranked by Lowest Percentage of National Highway System Mileage in "Poor" Condition (2019 Data)

Rank	State	Good	Fair	Poor
1	Nevada	72.3%	27.5%	0.2%
2	North Dakota	69.3%	30.5%	0.2%
3	Florida	47.1%	52.5%	0.4%
4	Georgia	49.2%	50.4%	0.4%
5	Idaho	53.2%	46.3%	0.5%
6	South Dakota	61.1%	38.4%	0.5%
7	***Missouri***	65.7%	33.7%	***0.6%***
8	***Indiana***	49.8%	49.5%	***0.7%***
9	North Carolina	46.5%	52.8%	0.7%
10	Utah	49.4%	49.9%	0.7%
14	***Minnesota***	60.2%	38.7%	***1.1%***
15	***Ohio***	56.3%	42.6%	***1.1%***
16	***Tennessee***	50.3%	48.6%	***1.1%***
19	***Kentucky***	56.0%	42.7%	***1.3%***
23	***Pennsylvania***	49.0%	49.5%	***1.5%***
	Median State	48.8%	51.9%	**1.7%**
33	***Wisconsin***	43.4%	54.1%	***2.5%***
35	***Iowa***	45.0%	52.1%	***2.9%***
41	Hawaii	20.2%	75.3%	4.5%
42	Maine	32.8%	62.7%	4.5%
43	Maryland	38.8%	56.2%	5.0%
44	Washington	25.8%	68.7%	5.5%
45	***Illinois***	37.8%	56.5%	***5.7%***
46	New York	24.2%	70.0%	5.8%
47	***MICHIGAN***	42.2%	50.2%	***7.6%***
48	New Jersey	39.8%	51.6%	8.6%
49	Louisiana	18.8%	71.8%	9.4%
50	Rhode Island	23.3%	61.6%	15.1%

Source: U.S. Government Accountability Office using FHWA Data

Michigan's non-Interstate highways (US and M routes) tend to be in worse condition than Interstate routes. **Table 3** (page 8) provides Interstate and non-Interstate pavement conditions as reported by MDOT.[16]

It is difficult to compare the efficacy of transportation programs between states. While states are required to report pavement conditions on the National Highway System using a standard federal metric, this reporting requirement does not extend to other roads. Additionally, the context and challenges of individual states can vary drastically with respect to funding levels, traffic load, and other constraints.

One approach to comparing states is provided by the Reason Foundation's Annual Highway Report series. Reason's Annual Highway Report ranking combines a series of individual metrics based on data available from the Federal Highway Administration. The Reason Highway Report combines metrics regarding pavement and bridge condition, funding levels, congestion, and safety. Using this method, Michigan ranks 27th among states in the most recent report.[17]

[12] See FHWA Highway Statistics Series, especially sections 12.4.1 through 12.4.11. Due to the unstructured and unfiltered nature of this data, additional analysis is beyond this present scope of work.
[13] Data from a U.S. Government Accountability Office (GAO) report using a classification system determined by FHWA.
[14] Rhode Island's outlier status might be explained by the small geographic size and corresponding highway network. With relatively few highway miles, a relatively short segment of highway falling into the poor category can cause a significant swing in percentage of highway rated as poor.
[15] U.S. Government Accountability Office. "National Highways: Analysis of Available Data Could Better Ensure Equitable Pavement Condition." July 2022. (Appendix 3.)
[16] Note that this table uses two different measures of pavement condition. While this disallows a direct comparison between interstate and non-Interstate NHS pavement conditions, this is how MDOT has made this data available.
[17] Feigenbaum, Bui, and Nguyen. 27th Annual Highway Report. Reason Foundation. April, 2023.

Table 3: Michigan National Highway System Pavement Condition Distinguished by Interstate and Non-Interstate Lane Miles (2019 Data)

Route Type	Good		Fair		Poor	
	Percent of Network	Lane Miles	Percent of Network	Lane Miles	Percent of Network	Lane Miles
Interstate[1] (PCM)	63.6%	3,834	31.8%	1,917	4.6%	277
Non-Interstate NHS[2] (IRI)	49.5%	8,121	31.4%	5,151	19.1%	3,134

Source: MDOT Transportation Asset Management Plan (TAMP) (2022)

As might be expected, Michigan ranks especially poorly in Interstate pavement condition and urban arterial pavement condition (**Table 4**). Reason's ranking included additional categories not shown in Table 4. Michigan also ranked poorly in the percentage of bridges ranked structurally deficient. Michigan ranks comparatively well in disbursement ratios (relative funding levels). Reason considers lower funding levels to be a positive attribute, as this implies efficiency of funds. Reason calculated disbursement ratios for maintenance, administration, and other. Michigan ranks 12th, 13th, and 15th, respectively.[18] Michigan also scored high in the rural fatality rate, ranking number five nationally.

Table 4: Reason Foundation's Highway State Rankings (2020 Data)

State	Overall Rank	Pavement Condition Rank			
		Rural Interstate	Urban Interstate	Rural Arterial	Urban Arterial
Virginia	1	5	19	3	16
North Carolina	2	15	15	10	7
Tennessee	***3***	***12***	***10***	***13***	***10***
Georgia	4	18	5	8	3
Connecticut	5	13	8	21	28
South Carolina	6	19	3	24	8
Kentucky	***7***	***16***	***16***	***14***	***6***
Florida	8	1	9	2	4
North Dakota	9	7	2	28	24
Utah	10	4	20	11	5
Missouri	***11***	***9***	***24***	***12***	***23***
Minnesota	***12***	***17***	***27***	***15***	***1***
Ohio	***17***	***33***	***32***	***17***	***39***
Indiana	***23***	***39***	***31***	***7***	***18***
MICHIGAN	***27***	***41***	***43***	***19***	***42***
Illinois	***29***	***26***	***34***	***44***	***32***
Iowa	***31***	***30***	***33***	***39***	***29***
Wisconsin	***33***	***36***	***37***	***35***	***43***
Pennsylvania	***41***	***42***	***39***	***33***	***35***
Rhode Island	42	3	18	49	49
Colorado	43	47	40	26	31
New Jersey	44	24	46	41	45
Oklahoma	45	35	38	40	25
Washington	46	45	22	30	44
California	47	46	47	42	50
Hawaii	48	n/a	50	48	33
New York	49	38	48	32	46
Alaska	50	48	12	50	

Note: Additional categories that factor into the overall rank include bridge conditions, funding efficiency, congestion, and fatality rates.

Source: Reason Foundation 27th Annual Highway Report (2023)

[18] It is unclear if Reason's methodology sufficiently accounted for varying percentages of principle arterial mileage under state jurisdiction. In Michigan, less than half of the state's principle arterial milage is owned by the state. Controlling for this may have increased Michigan's calculated disbursements ratios, lowering the overall ranking.

Act 51 of 1951 – Michigan's Road Funding Distribution Law

The state share of funding for Michigan's roads is derived primarily from state fuel taxes and vehicle registration fees. This revenue is then deposited into the Michigan Transportation Fund. MDOT is responsible to distribute this funding per requirements established in Act 51 of 1951. After various statutory deductions, MDOT retains 39.1 percent of the MTF, allocates 39.1 percent to counties, and 21.8 percent to cities and villages.

Act 51 was authored by the Automotive Safety Foundation (ASF), a national automotive industry lobby group.[19] The new language offered by ASF was superimposed over preexisting statute, some of which dates back to the 1800s.[20] There were many complications with this approach. Michigan's legislature has routinely amended the law to address weaknesses in the various revenue collection and distribution formulas of Act 51. The series of stop-gaps and carve-outs has resulted in a problematic road funding formula that presents substantial administrative challenges.[21]

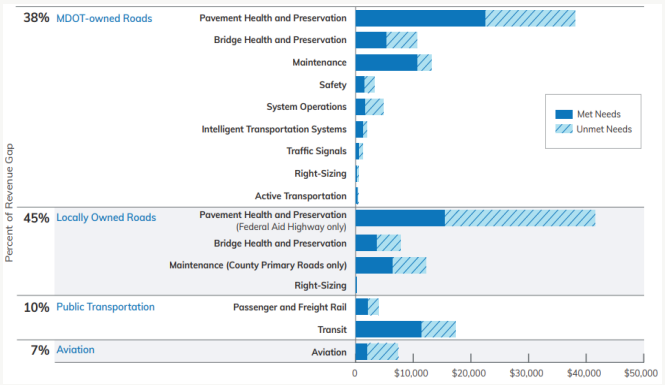
In addition to being inelegant, Act 51 is inefficient. The distribution formula allocates funding to county and municipal road agencies primarily based on road miles, population, and number of registered vehicles.[22] These metrics only tangentially relate to road funding needs. To better match allocated funding with needs, the distribution formula should at minimum consider lane-miles and truck traffic. Additional factors may include local material and labor costs, number and span of bridges in a district, as well as climatic and geological factors that impact life-cycle performance of pavements.

Act 51 is now over 70 years old and includes provisions that date back twice as long. Michigan should commission a comprehensive study on how best to meet transportation funding needs of the 21st century, as to inform a legislative overhaul or complete replacement of Michigan's transportation funding law. This is a necessary prerequisite to assure that available funding is put to best use.

Revenue Trends and Challenges

Michigan's State Long-Range Transportation Plan (SLRTP) estimates that revenue available for Michigan's transportation system will fall short of spending needs by $85 billion between 2020 and 2045.[23] Considering inflation since 2020, this is now about $100 billion dollars over 25 years, or a needs gap of $4 billion dollars a year (**Figure 2**). A separate estimate by the Michigan Infrastructure and Transportation Association (MITA) placed the funding gap, just for Michigan's road system, at $7.2 billion per year.[24] This would imply a need to more than double current funding levels.[25]

Figure 2: MDOT Estimates a Funding Gap of $85 Billion (in 2020 USD) Between 2020 and 2045



Source: MDOT. Michigan Mobility 2045 (2020-2045 State Long-range Transportation Plan) p. 30.

[19] Philip J. D'Anieri. Regional Reform in Historical Perspective: Metropolitan Planning Institutions in Detroit, 1950 – 1990. University of Michigan 2007

[20] Allen M. Williams (President, County and Local Roads Division, American Road Builders Association. Highway Engineer of Ionia County, MI.) "Efficient and Economical County Highway Administration." Purdue Road School. April 1956. p. 37.

[21] Eric Paul Dennis. "Fix the Damn Road Funding Formula." Citizens Research Council of Michigan. February 4, 2022.

[22] Citizens Research Council of Michigan. Report 405: Evaluating Michigan's Options to Increase Road Funding. February 2019.

[23] MDOT. Michigan Mobility 2045 (2020-2045 State Long-range Transportation Plan) p. 29.

[24] Public Sector Consultants. "Michigan Transportation Infrastructure Needs and Funding Solutions." March 2023.

[25] These estimates assessed only the existing system and do not include future liabilities incurred by current and planned highway expansion projects.

Such estimates deserve further scrutiny. According to FHWA data for highway funding at all levels of government in 2020, Michigan ranks 34th among states in per-capita spending (the 17th lowest). However, ranked by funding per miles of public road, as well as by lane-mile, Michigan ranks 21st.[26] There are additional factors that should to be considered to provide context to these numbers, such as historical funding levels that required deferred maintenance. But with recent increases in fuel taxes and registration fees, Michigan's road network, per mile, is now better funded than the median state and most of Michigan's peer states (**Table 5**).

Table 5: States Ranked by Most Funding per Lane-mile of Public Road, All Levels of Government (2020 data)[27]

State	Total Road Funding ($1,000s)	Rank	$ per Capita	Rank	$ per Mile	Rank	$ per Lane-Mile	Rank
Delaware	2,845,696	30	2,874	1	436,055	1	201,551	1
New Jersey	10,667,106	7	1,148	12	273,579	2	125,214	2
Hawaii	960,698	48	660	40	213,441	3	98,000	3
New York	23,182,516	3	1,148	13	202,990	4	96,263	4
Maryland	5,333,716	16	863	24	164,469	5	74,865	5
Massachusetts	5,677,961	15	808	29	154,230	7	72,978	6
Pennsylvania	17,454,746	4	1,342	6	144,439	8	69,254	7
California	27,275,248	1	690	38	155,360	6	68,770	8
Rhode Island	853,690	49	778	33	141,691	10	67,019	9
Connecticut	3,059,001	26	848	27	141,785	9	66,646	10
Illinois	***11,012,518***	***6***	***860***	***25***	***75,432***	***17***	***35,901***	***17***
MICHIGAN	***7,591,689***	***8***	***753***	***34***	***62,207***	***21***	***29,621***	***21***
Ohio	***7,307,414***	***12***	***619***	***44***	***59,414***	***23***	***27,841***	***23***
Median State	**3,151,248**		**859**		**51,635**		**24,853**	
Wisconsin	***5,712,820***	***14***	***969***	***18***	***49,354***	***27***	***23,851***	***27***
Indiana	***4,384,151***	***19***	***646***	***41***	***45,146***	***30***	***21,592***	***30***
Minnesota	***6,116,697***	***13***	***1,153***	***11***	***43,088***	***33***	***20,961***	***33***
Kentucky	***2,874,075***	***29***	***638***	***42***	***35,923***	***37***	***17,195***	***37***
Tennessee	***2,897,523***	***28***	***419***	***50***	***30,125***	***38***	***14,211***	***38***
Missouri	***3,840,743***	***22***	***624***	***43***	***28,983***	***39***	***13,811***	***39***
Iowa	***3,243,494***	***25***	***1,017***	***16***	***28,244***	***40***	***13,763***	***40***
Alabama	2,647,705	33	527	47	26,432	41	12,635	41
Arkansas	2,409,149	35	800	30	24,275	42	11,803	42
Idaho	1,227,663	45	668	39	23,041	44	11,257	43
New Mexico	1,682,104	39	794	31	23,333	43	11,158	44
Nebraska	2,091,481	37	1,066	14	21,939	45	10,776	45
Mississippi	1,650,910	40	558	45	21,299	46	10,181	46
Kansas	2,723,684	32	927	19	19,439	47	9,520	47
Montana	1,353,285	42	1,248	9	18,415	48	9,014	48
South Dakota	1,242,498	44	1,401	5	15,209	49	7,481	49
North Dakota	1,005,632	47	1,291	7	11,372	50	5,607	50

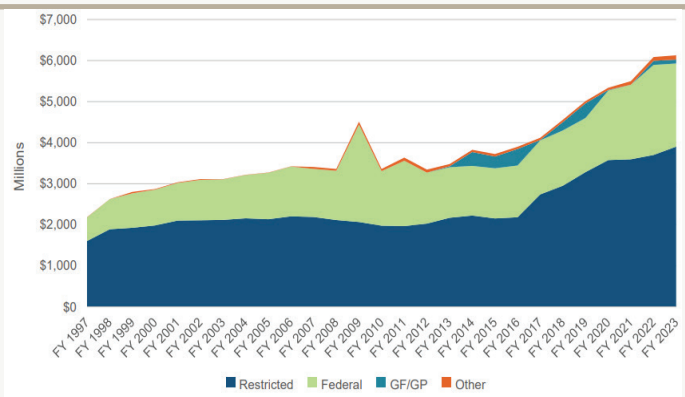
Source: FHWA Highway Statistics 2021 Table HF-1 and 2020 Table PS-1

There is much detail and context behind these top-level figures. Truly understanding relative budget needs would require analysis of the number of large bridges in each state, traffic demand, climactic and geological factors, as well as historical funding levels that contributed to maintenance backlogs. However, it is not evident that Michigan remains a comparatively underfunded state.

Analysis of the state transportation budget confirms that funding has increased meaningfully in recent years. Since 2019, Michigan's Transportation Fund has increased from about $5 billion to over $6.1 billion (**Figure 3**).[28]

[26] FHWA Office of Highway Policy Information. Highway Statistics 2021 Table HF-1 and 2020 Table PS-1.
[27] Funding data is from 2020. Population and system length data is from 2019, as 2020 data was not yet available in FHWA tables at time of analysis.
[28] William Hamilton. Budget Briefing: Transportation. House Fiscal Agency. February 2023.

Figure 3: Michigan Transportation Fund Gross Appropriations (1997-2023)



Source: House Fiscal Agency

Although transportation funding in Michigan has increased substantially in recent years, there is interest in finding more. Options to increase revenue include the following.

- **Increase Fuel Taxes**. Fuel taxes remain a significant component of transportation revenue—nearly 40 percent in 2022. Fuel taxes were increased in 2015 and will now continue to increase at the rate of inflation. Although fuel tax revenue is currently at record high levels, the revenue potential of fuel taxes will likely slowly decrease in the future as vehicles become more efficient and electric vehicles become more popular.

- **Increase Registration Fees**. Registration fees contribute around 40 percent of state restricted transportation revenue (about the same as fuel taxes in recent budgets). Registration fees were increased 20 percent in 2015 but are not scheduled to increase with inflation. A registration surcharge for electric vehicles was also adopted.

- **Increase Truck Registration Fees**. Most pavement damage is caused by heavy trucks. Michigan's $1,992 per year fee for an 80,000-pound truck is less than in Wisconsin ($2,560), Indiana ($2,604), and especially Illinois ($3,191).[29] This, combined with Michigan's more permissive weight restrictions, implies that trucks in Michigan do not create as much revenue relative to the pavement damage costs they impose. This is true in all states,[30] but especially so in Michigan.

- **Non-Transportation-Related Taxes.** Much of the historical impetus for funding transportation with dedicated revenue sources (e.g., fuel taxes) was so that road funding would not have to compete with other needs in budget deliberations.[31,32]This helps to provide funding certainty needed to develop long-term plans. However, in recent decades, the federal government and many states, including Michigan, have subsidized highways with ad hoc and dedicated transfers from the general fund, as dedicated revenue has not kept pace with funding needs. The 2015 transportation funding package earmarked $600 million dollars annually from state income tax revenues. Further, in 2018, 35 percent of marijuana tax revenues was earmarked for roads and bridges.

- **Tolling**. Besides a few bridges, Michigan does not toll roads. This is in contrast to nearby states like Illinois, Indiana, and Ohio. MDOT has administered a tolling feasibility study that was published in January 2023.[33] While the top-level results suggest it is feasible to develop a tolling program in Michigan, analysis of the report methodology call this into question. Conclusions of feasibility rest on multiple questionable assumptions and outdated traffic projections. Notably, current Michigan law allows highway tolling only for hypothetical connected-automated vehicle (CAV) lanes.[34]

[29] The Official Guide to MDOT 2021.
[30] Federal Highway Administration, Office of Policy and Governmental Affairs. Addendum to the 1997 Federal Highway Cost Allocation Study. May 2000.
[31] Philip J. D'Anieri. Regional Reform in Historic Perspective: Metropolitan Planning Institutions in Detroit, 1950-1990. 2007.
[32] Bradford C. Snell. American Ground Transport: A Proposal for Restructuring the Automobile, Truck, Bus, and Rail Industries. 1974.
[33] Michigan Statewide Tolling Study
[34] Eric Paul Dennis. "A Reality Check on Michigan's Autonomous Vehicle Future." November 10, 2022.

- **Road Usage Charges (RUC).** RUC (also known as vehicle-miles-travelled [VMT] tax) is similar to tolling, but applied to an entire road network rather than a single highway or bridge. RUCs have been studied and piloted for decades, but not implemented at scale. Barriers include privacy trade-offs and administrative cost burdens.[35] Michigan is currently engaged in a project to assess public acceptance of RUC fees.[36]

- **Leasing ROW and communications networks.** Michigan and local governments have as much land dedicated to transportation ROW that might be leased for complimentary uses such as power generation[37] and distribution. MDOT also maintains a statewide fiber communication network that may have reserve bandwidth that could be leased. MDOT has recently released an RFP for a study investigating the revenue-generation potential of state-owned communication lines.[38]

- **Automate Traffic Enforcement.** Transportation departments have historically been inclined to address speeding by instituting "rational speed limits." Specifically, they measure how fast cars go when the speed limit is not enforced and then set the speed limit for the 85th percentile of that speed.[39] This has resulted in higher and higher speeds, making traffic increasingly dangerous.[40] Some states use speed and red-light cameras to automate traffic enforcement. Research shows this to improve compliance, increase safety, and the fines generated could be used for transportation programs.[41]

- **Permit local fuel tax.** Michigan law currently restricts municipalities from levying local fuel taxes. Lifting this restriction could help local road agencies create revenue for local roads, which tend to be the most underfunded. Some type of excise motor fuel tax is authorized to be levied by local governments in 11 states. Other approaches include percentage taxes and supplier taxes; taxes can apply differently to different types of motor fuel (e.g., gasoline, diesel, biodiesel). Local motor vehicle license taxes are authorized in some form in 38 states.[42]

- **Redirect Sales Tax on Fuel**. Michigan could increase road funding by over $1 billion annually by redirecting sales taxes on fuels to the Michigan Transportation Fund. However, this would reduce funding for schools and revenue sharing with local governments.[43]

Beyond Revenue

Most discussions of transportation policy in Michigan focus on creating additional revenue. It may be the case that current levels are insufficient. However, there are many opportunities to make better use of existing revenue.

Reform Truck Weight Limits

Michigan's highest-in-the-nation gross truck weights are responsible for accelerating damage to state roads and bridges. MDOT claims that "pavement damage caused by a vehicle is not related to [vehicle weight], but to axle loadings," implying that because these heavier trucks distribute the weight over additional axles, they do not impose additional damage.[44] Engineering analyses show that this is only true for the pavement surface. The base-layers underneath the pavement surface are impacted by overall vehicle weight. Further, if the pavement surface is rough, dynamic effects do impose additional forces on the pavement surface related to overall vehicle weight and these are amplified with heavier trucks.[45,46]

[35] Eric Paul Dennis. "Road Usage Charging is a Fraught Strategy to Fund Michigan's Roads." Citizens Research Council of Michigan. January 11, 2023.
[36] Per conversation with MDOT's consultant, Via.
[37] Tina Hodges and Amy Plovnick. "Renewable Roadsides." Public Roads. USDOT FHWA. 2019.
[38] MDOT Research Administration SPRII RFP Announcement. 02/27/2023. REQ3873 - OR23-012 - Revenue Opportunities from MDOT Fiber Infrastructure and Other Utility Types.
[39] MDOT – Speed Limits.
[40] Freakonomics Podcast. "Why Is the U.S. So Good at Killing Pedestrians?" July 5, 2023.
[41] If the main policy goal is highway safety, using physical design elements that do not encourage speeding is generally a more effective option, but often requires costly construction projects.
[42] Citizens Research Council of Michigan, "Diversifying Local-Source Revenue Options in Michigan." Report 399. February 2018.
[43] Bob Schneider. "Fixing the Damn Roads: It's Time to Eliminate the Sales Tax on Motor Fuel." Citizens Research Council of Michigan. December 1, 2022.
[44] MDOT Truck Weights in Michigan. 2017.
[45] Pavement Interactive – ESALs.
[46] Paul Egan. "Experts weigh in on how much Michigan's heavy trucks damage the state's roads." Detroit Free Press. April 19, 2019.

MDOT also notes that if truck weight restrictions were tightened to federal standards, that would put more trucks on the road to compensate for decreased weight limits. This is likely true, but Michigan currently has some of the lightest truck traffic in the nation. Truck traffic in Michigan's urban areas is 5.6 percent of vehicle-miles-travelled, the 5th lowest in the nation. In rural areas, trucks make up 9.6 percent of vehicle-miles-travelled, the 7th lowest in the nation (Table 6).[47]

Trucks impose more damage on Michigan's roads than they generate revenue to fix them.[48,49] It is near-certain that Michigan's truck weight laws amplify this. The effects are complex, and it is impossible to estimate the amount of damage without a detailed study. While MDOT knows the number of trucks registered to haul overweight loads, it does not know where these trucks travel. This data should be collected and used for planning and design purposes, at minimum. This appears to be 'low hanging fruit' among options to improve pavement conditions in Michigan.

Table 6: States Ranked by Percentage of Truck Traffic, Urban and Rural (2019 Data)

		Urban VMT			Rural VMT
Rank	State	Truck Percentage	Rank	State	Truck Percentage
1	Utah	18.2%	1	Utah	29.3%
2	New Mexico	16.3%	2	North Dakota	25.3%
3	Oklahoma	13.8%	3	New Mexico	23.6%
4	West Virginia	13.2%	4	Oklahoma	23.1%
5	South Carolina	12.0%	5	Oregon	22.3%
6	Massachusetts	12.0%	6	Illinois	22.2%
7	Georgia	11.7%	7	Wyoming	20.9%
8	New Jersey	10.6%	8	Nevada	20.9%
9	Louisiana	10.6%	9	Arizona	20.4%
10	California	9.9%	10	Kansas	20.2%
14	***Wisconsin***	***9.5%***	***12***	***Indiana***	***19.4%***
17	***Ohio***	***9.0%***	***17***	***Missouri***	***17.2%***
19	***Kentucky***	***8.8%***	***19***	***Iowa***	***16.6%***
23	***Minnesota***	***8.4%***	***21***	***Pennsylvania***	***15.7%***
			23	***Kentucky***	***15.0%***
Median State		**7.9%**	***24***	***Ohio***	***14.6%***
27	***Missouri***	***7.8%***		**Median State**	**14.4%**
29	***Tennessee***	***7.6%***			
32	***Illinois***	***7.4%***	***29***	***Wisconsin***	***14.0%***
36	***Iowa***	***6.8%***	***30***	***Tennessee***	***13.3%***
38	***Indiana***	***6.3%***	***34***	***Minnesota***	***12.0%***
41	Nevada	6.2%	41	Delaware	10.2%
42	Maryland	6.0%	42	New Jersey	9.7%
43	Maine	6.0%	43	Massachusetts	9.7%
44	Idaho	5.7%	***44***	***MICHIGAN***	***9.6%***
45	Virginia	5.7%	45	Vermont	9.5%
46	***MICHIGAN***	***5.6%***	46	New Hampshire	9.2%
47	Mississippi	5.4%	47	Alaska	9.0%
48	***Pennsylvania***	***4.7%***	48	Maryland	8.7%
49	North Dakota	4.4%	49	Connecticut	8.0%
50	South Dakota	3.0%	50	Hawaii	4.9%

Source: FHWA, Office of Highway Policy. Highway Statistics 2020. Table PS-1.

[47] FHWA, Office of Highway Policy. Highway Statistics 2020. Table PS-1.
[48] Paul Egan. "Fixing Michigan's Crumbling Roads: What about heavy trucks?" Detroit Free Press. March 1, 2019.
[49] An overview of truck-related revenue is provided by: William Hamilton, "Transport Permits and the Regulation of Vehicle Size, Weight, and Load." MI House Fiscal Agency. February 2018.

Emphasize Construction Quality Control and Enforce Warranties
The Michigan Office of the Auditor General (OAG) reported in 2021 that MDOT does not always enforce warranties to require corrective action on faulty construction work.[50] Related, the OAG found that MDOT has not evaluated the efficacy of its warranty program, including on projects where warranties are not required by regulations.[51]

A separate OAG audit found that MDOT often does not verify that gravel used in road construction complies with engineering standards and contractual requirements.[52] Other audits have identified additional quality control issues.[53]

Roads are engineered systems. If they are not constructed to engineering specifications, they will not perform as expected and will fail prematurely and/or impose increased maintenance costs. Other aspects of contract administration and project inspection may be similarly afflicted but are have not been externally audited.

Focus on Core Objectives
MDOT and some local road agencies have recently expended significant resources and attention pursuing projects with questionable value to transportation system condition and operation. Such projects include experimental connected vehicle technology, [54] autonomous vehicles, connected-autonomous vehicles (CAVs)[55], automated busses,[56] and experimental aircraft.[57]

Innovative thinking and experimentation is laudable, but should consider resource constraints and the public interest.

Transportation Asset Management

In 2002, Michigan's legislature created the statewide Transportation Asset Management Council (TAMC) and charged it with implementing a "coordinated, unified effort" for statewide asset management program to better predict funding needs for the entire state road network.[58]

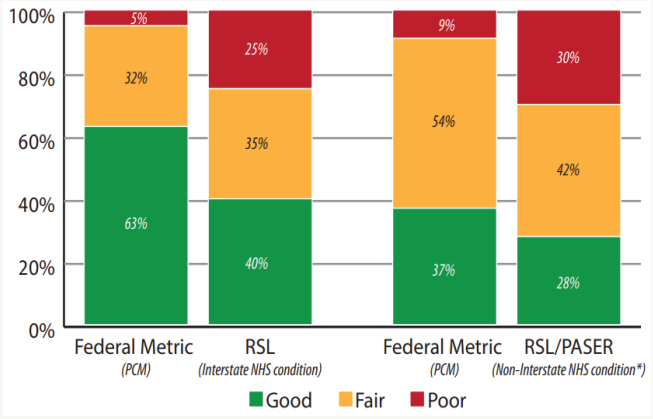
TAMC was faced with a difficult task, as the approach must be acceptable to MDOT and all of Michigan's 614 local road agencies. The approach chosen was a single metric called "Pavement Surface Evaluation and Rating (PASER)," developed in the 1980s. PASER is a 1-10 rating measured via "windshield survey."[59] However, use of PASER as a basis for TAM may impede implementation of best practices that require objective engineering-quality metrics. PASER ratings are subject to a variety of human biases, and cannot be disaggregated into individual pavement distresses, which means the PASER rating cannot be used to determine how the pavement is failing, how best to remediate it, or what rate it can be expected to further degrade.

MDOT reports PASER ratings to TAMC but does not emphasize PASER for investment decision support.[60] It uses a novel approach to predicting pavement remaining service life (RSL).[61] Historically, MDOT's RSL has been based on a proprietary distress index (DI) calculated via an engineering-quality distress survey. However, MDOT stopped collecting DI in 2019 and does not plan to resume (due to costs). For the time being, RSL is being assumed based on extrapolation of 2019 data.[62]

As shown in Figure 4, below, the RSL/PASER measures used by Michigan rate pavements much differently than federal metrics that have been promoted by U.S. Department of Transportation and Association of American State Highway Authorities (AASHTO). Adopting metrics that categorize such a high percentage of pavement as 'poor' makes it difficult for road agencies to prioritize investments and identify performance differences related to traffic loading, design, materials, construction quality, or maintenance practices.

[50] Michigan Office of the Auditor General. Use of Warranties – Michigan Department of Transportation. March 2021.
[51] Michigan Office of the Auditor General. Use of Warranties – Michigan Department of Transportation. December 2022.
[52] Michigan Office of the Auditor General. Aggregate Quality Process-Michigan DOT. December 2022.
[53] Paul Egan. "Official: Lobbyist who steered $50K gravel study should refund state for its cost." Detroit Free Press. Oct 2, 2019.
[54] Kirk Steudle, Peter Sweatman, and Steve Underwood. Team Michigan: Connecting Vehicles and Partners. 2008.
[55] Eric Paul Dennis. "A Reality Check on Michigan's Autonomous Vehicle Future." Citizens Research Council of Michigan. November 10, 2022.
[56] Grace Turner. "MDOT, Planet M Join Automated Bus Consortium in California to Launch Pilots." DBusiness. June 4, 2019.
[57] MEDC. Press Release: Gov. Whitmer announces air mobility corridor development in Michigan and Ontario. January 5, 2022.
[58] Act 499 of 2002.
[59] Pierce, McGovern, and Zimmerman. Applied Pavement Technology, Inc. (FHWA) "Practical Guide for Quality Management of Pavement Condition Data Collection." 2013.
[60] Per conversation with MDOT Planning Department.
[61] MDOT Transportation Asset Management Plan (TAMP) 2022.
[62] MDOT Transportation Asset Management Plan (TAMP) 2022. p. 19.

Figure 4: Pavement condition ratings based on the federal pavement condition metric (PCM) and Michigan's RSL/PASER approach



Source: MDOT Transportation Asset Management Plan (2022)

MDOT is now in the process of transitioning to an asset management approach that uses the standard federal pavement condition metric. However, it appears that the statewide approach to pavement condition assessment, orchestrated by TAMC, will continue to utilize PASER ratings. This will make it difficult to understand the comparative condition of Michigan's roadway pavement. Additionally, PASER ratings provide questionable decision support for local agencies that emphasize the metric for their own asset management programs, as TAMC encourages.

Michigan's Transportation Asset Management Program as administered by TAMC deserves an independent review. It is not clear that the program has fulfilled its legislative intent. This could be part of a broader analysis of Act 51, and a restructuring of state transportation funding to assure that funding is appropriated efficiently. This research project should be administered outside of MDOT or TAMC (e.g., by DTMB). The recent independent analysis of the Edenville Dam collapse[63] can serve as an example for such a project.

Water Infrastructure

Water infrastructure can be sub-categorized into,

1. Drinking water provision,
2. Stormwater management systems, and
3. Sanitary sewers and wastewater treatment.

This taxonomy is more representative of budget divisions than reality. All water systems are connected and relate to each other, as well as to natural resources and the environment. There are also many common challenges in funding, operating, and maintaining these systems.

The Michigan 21st Century Infrastructure Commission Report (2016) said this about the state of Michigan's water infrastructure:

"A 21st century water infrastructure system begins with being able to identify the location and condition of Michigan's water, sewer, and stormwater infrastructure. This knowledge and data will identify infrastructure shortcomings to develop a long-range plan for a safe, reliable, cost-effective and efficient system."[64]

In other words, the extent and condition of Michigan's water infrastructure is largely unknown. Better understanding the problem is appropriately seen as prerequisite to fixing it.[65] A rough estimate of the "funding gap" to maintain water infrastructure in functional condition and avoid disruptive failures is probably somewhere between $1 billion and $5 billion annually—but much context is needed to make such estimates meaningful.[66]

[63] Final Forensic Report on 2020 Edenville and Sanford Dam Failures Released. 2022.
[64] Michigan 21st Century Infrastructure Commission Report. 2016. p. 96.
[65] Michigan's paucity of water infrastructure data is typical. As this is underground infrastructure, often installed before digital record keeping, it is common for infrastructure owners to have very incomplete data on their systems.
[66] The difficulty in estimating funding-needs is partially demonstrated in: Michigan's Water Infrastructure Investment Needs (2016) by Public Sector Consultants.

Traditionally, the state's main role in water infrastructure has been limited, primarily as a regulatory authority for the Clean Water Act and related permitting. Water infrastructure is typically owned by local governments. The state has limited authority or insight into the details of these systems. Many smaller systems are privately owned (e.g., planned developments like subdivisions and industrial parks.) As such, there is wide variation in the condition of water infrastructure systems and what is known about them. Some water infrastructure owners have excellent data on their system, while others may have none at all. Data is not aggregated at the state level.

There are now efforts to expand the state's role. Michigan's Water Asset Management Council (WAMC) was created in 2018 to "lead, guide, and assist communities in the development and/or enhancement of their drinking water, wastewater, and storm water asset management programs."[67] The WAMC is responsible for the development of asset management templates, as well as annual reporting to the Michigan Infrastructure Council on the asset condition and investment of water infrastructure across the state.[68] The Council has been working to develop a meaningful program to support statewide water infrastructure asset management and consistent reporting.[69]

Additionally, the Michigan Department of Environment, Great Lakes, and Energy (EGLE) has recently assumed a more active role in water infrastructure funding through the grant-based MI Clean Water Plan. This is a competitive grant program, awarded based on a variety of factors.[70]

The delivery of water to homes and businesses has become more expensive due to lower-density development ("sprawl"). Until about 1950, most residential and commercial development was built in a relatively dense grid pattern. Post 1950, transportation and city planners in the U.S. adopted an assumption that new urban forms should prioritize automobile travel.[71] Newer developments were less dense, often incorporating curvy roads and dead-end cul-de-sacs (which is less efficient for infrastructure provision). At the same time, established cities lost population, leaving only a fraction of the population that the infrastructure was built to serve.[72] As a result, the average rate payer in both urban and suburban areas is now responsible for more significantly infrastructure than in previous decades. Underinvestment and deferred maintenance are ubiquitous across Michigan's suburban communities, rural systems, and small community systems.[73,74]

Small private systems, including individual wells and septic systems are not tracked by the state, but nevertheless create health, environmental, and affordability issues for individuals in those situations, and the surrounding community.[75] It will likely require decades of focused attention to attain an appropriate understanding of water infrastructure in Michigan and develop rational long-term approaches to funding.

Drinking Water Provision

Water is essential for life. It is critical that Michigan citizens have access to safe tap water. Tap water must be clean not only for drinking and cooking, but also for bathing, as some contaminants can impact human health through inhalation of steam while showering.[76,77]

Municipal drinking water is usually pulled from surface waters such as lakes and rivers, but large wells are also used in some systems. The 'raw' water is then treated to meet drinking water standards for health and safety and delivered to end users through a distribution system of pipes, pumps, and storage tanks.

Treating and delivering drinking water is more expensive now than it was in previous decades. Part of this is because water quality and pollution control regulations have become much more stringent. Not only is more known about human health risks from water pollu-

The average Michigander's water bill has more than doubled since 1980 and still does not cover the cost of service.

[67] EGLE. WAMC.
[68] Water Asset Management Council 2021 Annual Report. June 7, 2022.
[69] Idem. p. 2-3.
[70] https://www.michigan.gov/egle/regulatory-assistance/grants-and-financing/mi-clean-water-plan
[71] Peter Norton. Fighting Traffic: The Dawn of the Motor Age in the American City. MIT Press. 2011.
[72] U.S. GAO. Water Infrastructure: Information on Selected Midsize and Large Cities with Declining Populations. 2016.
[73] Lester Graham. "Many Rural Towns Have Neglected Drinking Water Systems for Decades." Circle of Blue. May 3, 2022.
[74] Kelly House. "Water Woes Loom for Michigan Suburbs, Towns After Decades of Disinvestment." Circle of Blue. May 3, 2022.
[75] Lester Graham. "Michigan's Lack of Septic System Regulations is Causing Problems for Some of its Most Pristine Lakes." May 4, 2022.
[76] Yue Zhuo et al. "Particle Size Distribution and Inhalation Dose of Shower Water Under Selected Operating Conditions." Inhal Toxicol. 2007 Apr; 19(4): 333–342. doi: 10.1080/08958370601144241
[77] U.S. EPA. Inhalation Exposure to Contaminants from a Water Distribution System. September 2015.

tion, but in many cases the source water has become increasingly polluted; this impacts wells, reservoirs, rivers, and even Great Lakes intakes. Public water utilities must frequently test for contaminants and are responsible to correct deficiencies through a treatment process. This can be a significant cost burden, especially for smaller systems.

Compared to previous decades, water utilities must now deliver a higher quality product, often with lower quality source water, across more infrastructure per rate payer. The oldest parts of the system are nearing or passed expected service life and may need complete replacement. Water mains that are past their life cycle may slowly leak, costing money that is not recuperated in rates. They may also suddenly burst, requiring costly emergency repairs. It is not surprising that the average Michigander's water bill has more than doubled since 1980 and still does not cover the cost of service.[78]

Around 25 to 30 percent of Michiganders get drinking water from small community sources or private wells.79 In these cases, inspection is typically only required when a new well is installed. Property owners are then responsible to assure that the water being pulled from the well is safe. Due to increasingly contaminated groundwater, many citizens may be at risk from harmful pollutants. Public agencies are engaged in a long-term effort to understand the scope and scale of the problem.

Contaminants can also be introduced by old plumbing within homes and buildings. The problem with lead contamination is largely due to lead service lines that connect the public distribution network to an end-user. There is now a statewide mandate to replace lead service lines.[80] However, leaded plumbing was used for decades. Many older homes and buildings may be at risk from lead contamination despite replacement of the service line.[81] Public agencies are working to get a better picture on the extent of this problem, but much remains unknown.

Sanitary Sewers and Wastewater Treatment

When water flows down a drain from a home or business, it enters wastewater conveyance and treatment systems, also known as sanitary sewers. About 70 to 75 percent of Michigan households are served by approximately 1,100 municipal wastewater treatment systems across the state. These systems consist of miles of sanitary or combined sewer networks, pump stations, lift stations, and wastewater treatment plants.

Michigan's sanitary sewers are subject to many of the same challenges as water distribution systems related to land use changes over recent decades, including depopulation of urban centers and sprawling suburban development. Many systems are built-out beyond the financial ability to maintain them. Government regulations and public expectations have made treating wastewater before it can be discharged much more expensive than in previous decades. Data regarding the condition of networks is often incomplete.

Private Septic Systems

About 25 to 30 percent of Michiganders are not connected to municipal wastewater sewer systems and use private septic systems.[82] This approach requires individuals to be responsible for their own wastewater treatment, rather than public infrastructure. Repair of aging septic systems can be a cost burden for many families, and often, it is simply not done. Michigan is unique in that there are no statewide regulations of private septic systems. Aged and failing septic systems can leak untreated or partially-treated sewage, leading to environmental issues such as nutrient pollution of lakes and watersheds.[83]

> Michigan is unique in that there is no state-level regulation of private septic systems.

Stormwater Management Systems

Stormwater infrastructure is comprised of a variety of systems and practices designed to manage runoff from wet weather events (rain and snow-melt). Stormwater management relies on traditional infrastructure like storm sewers and wastewater treatment plants, but also natural features such as wetlands.

[78] Jennifer Read et al. Water Service Affordability in Michigan: A Statewide Assessment. January 2022.
[79] Michigan 21st Century Infrastructure Commission Report. 2016. p. 109.
[80] Michigan.gov. Lead Service Line Replacement.
[81] Garret Ellison. "Hamtramck, other Michigan water systems flagged for toxic lead." MLive. October 29, 2021.
[82] MDEQ. "Sustaining Michigan's Water Heritage." October 2016. p. 39.
[83] Tip of the Mitt Watershed Council and Health Department of Northwest Michigan. The Septic Question. 2016.

Stormwater management systems may include:

- Storm sewers
- Combined storm/sanitary sewers (legacy systems)
- Storm drains
- Ditches, drains, and swales
- Retention and detention ponds
- Permeable pavements
- Pump stations and lift stations
- Engineered and natural wetlands
- Residential sump pumps
- Rain gardens and other green infrastructure
- Maintenance practices

Much of Michigan's storm sewer infrastructure was built with federal subsidies following the 1972 Clean Water Act (CWA). Prior to the Clean Water Act, there was minimal treatment of sewage before being discharged into surface waters. Rivers caught on fire[84] and Lake Erie was declared "dead."[85] The CWA required states to regulate and greatly reduce water pollution. Federal funding was made available to separate storm and sanitary sewer systems so that sanitary sewage could be treated before being released back to the environment.

It was expected that maintenance and eventual replacement costs would fall to the owners of that infrastructure (i.e., local governments). The stormwater infrastructure that was installed during this build-out period is now approaching 50 years old and in need of replacement. Many infrastructure owners have not budgeted for this, causing widespread backlogs of maintenance and needed repairs.

There are physical and practical limits to how much stormwater can be removed from a highly paved urban area through artificial drains, particularly if these drains are not maintained. Undersized or poorly maintained storm sewers can exacerbate flooding issues, particularly in urban areas with a lot of impermeable paved surfaces. Further, storm drains wash grease, grime, and litter from roads and other impervious surfaces directly into water bodies. Removing these pollutants to turn raw surface water into municipal drinking water often adds additional costs.

Engineers and planners are increasingly utilizing "green infrastructure" that mimics stormwater management of a natural ecosystem. This approach can be environmentally beneficial and cost-effective, but requires thoughtful design and ongoing maintenance.[86] There are also practical limits to what can be accomplished through green infrastructure—water can percolate through soil only so quickly.

Urban flooding and polluted runoff are now frequent concerns in Michigan and across the nation. This promotes additional issues such as black mold in basements, harmful algal blooms in surface waters, and beach closures due to e. Coli contamination.[87]

Complicating the challenges, extreme precipitation events have increased in recent decades, and will likely continue to increase because of climate change. Michigan is challenged to maintain and upgrade stormwater infrastructure not only to protect property and people, but to prevent contaminants from polluting surface waters.

Stormwater Utilities (SWUs)

Michigan is not taking full advantage of one approach to asset management and funding of stormwater systems: a Stormwater Utility (SWU). A SWU is a formal approach to planning, funding, and managing stormwater infrastructure. There are currently ten SWUs in Michigan. Many more Michigan municipalities are aware of the benefits of establishing a SWU, but are hesitant to do so because certain aspects of Michigan law open SWUs to legal challenges. Michigan currently has 10 SWUs. By comparison, Wisconsin has over 200 SWUs; Minnesota and Ohio each have over 100. The potential to affirm the legality of SWUs in state legislation represents an important opportunity to improve funding of stormwater infrastructure.[88] Currently, Michigan's SWUs follow municipal boundaries. Another approach is to develop multi-jurisdictional SWUs related to watershed boundaries to more efficiently match rates to imposed costs.

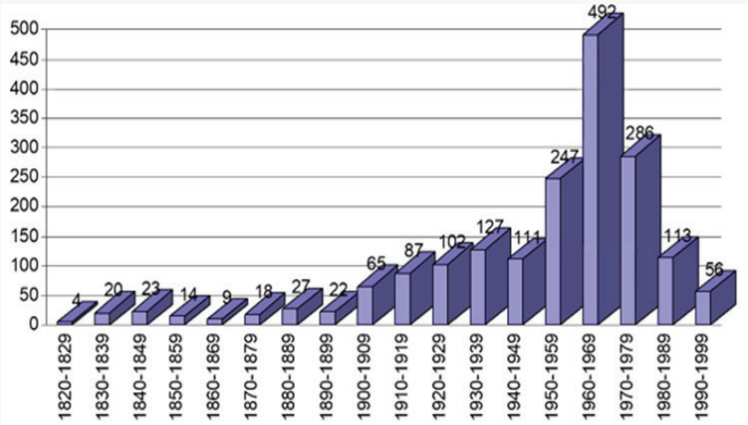
[84] John Hartig. "Great Lakes Moment: Five decades since the infamous Rouge River fire." GreatLakesNow. October 10, 2022.
[85] Michigan CLV. "#OurLegacy: The near-death of Lake Erie and its uncertain future." July 12, 2018.
[86] SEMCOG. "Low Impact Development Manual for Michigan." 2008.
[87] Environment America. Safe for Swimming? July 5, 2023.
[88] Eric Paul Dennis. "Creating Stormwater Utilities Would Help Reduce Future Flood Damage." Citizens Research Council of Michigan. April 11, 2022.

Dams and Flood Control Infrastructure

Michigan has 2,544 dams in the Michigan Department of Environment, Great Lakes, and Energy's (EGLE's) tracking database (as of April 2023).[89] It is unclear how complete this database is, as EGLE is continually adding newly discovered dams. Of the dams tracked in EGLE's database, about 1,500 are not actively inspected because they do not meet size or hazard requirements.[90]

Nearly half of the dams in EGLE's database were constructed between 1950 and 1979. A typical service life expectancy of a dam is about 50-60 years before requiring extensive rehabilitation. As such, many of Michigan's dams are nearing or have passed the end of their expected service life.

Figure 5: Construction Date of the 1,861 Dams Tracked by EGLE



Source: Michigan Dam Safety Task Force Report (2021).

Additionally, 92 structures are regulated by the Federal Energy Regulatory Commission (FERC), and thus not tracked by EGLE. These are typically large dams generating hydroelectric power. Many large dams were originally constructed for hydroelectric power generation, the economics of which are no longer favorable. Consumers Energy, alone, owns and operates 13 hydroelectric dams and is studying options for future projects, possibly including removal.[91,92] When hydroelectric powerplants are shuttered, regulatory jurisdiction reverts to EGLE.

A 2018 state inspection of the Edenville Dam that collapsed and flooded Midland found it to be in "fair" condition- about 18 months before catastrophic failure.

Most dams in Michigan are rated in "fair" condition. However, these ratings are often based on incomplete or outdated inspections. Many inspections have been self-reporting by the dam owners.

A 2018 state inspection of the Edenville Dam that collapsed and flooded Midland found it to be in "fair" condition—about 18 months before catastrophic failure.[93] Following the collapse of the Edenville dam, Michigan has increased efforts to understand the condition of dams around the state. A Dam Safety Task Force Report, submitted in February 2021, found that: "Of the 85 high hazard potential dams, 70 percent are in satisfactory condition, 22 percent are in fair condition, and 7 percent (or six dams) are in poor condition."[94] The report did not provide conditions of the other regulated (non-high hazard) dams in Michigan.[95]

Removal is likely the best option for many large dams unless they have become valued recreational and cultural amenities. A focused dam removal program could improve ecosystem functioning, reduce future liabilities, and establish best practices that can be adopted across the country. For example, the Boardman River restoration

[89] Database of Michigan Regulated Dams. This does not include large hydroelectric dams, which are regulated by Federal Energy Regulatory Commission. Additionally, many smaller dams are not listed because the state has no records on them. The database is frequently updated as more are identified.
[90] The U.S. Army Corps of Engineers (USACE) has its own method of determining risk and lists 1,047 dams in Michigan with significant hazard potential. (USACE National Inventory of Dams.)
[91] Consumers Energy. Future of Hydroelectric in Michigan.
[92] Kelly House. "Uncertainty for Michigan rivers, residents as Consumers reconsiders its 13 dams." Bridge Michigan. Nov 15, 2022.
[93] France et al. Independent Forensic Team. Investigation of Failures of Edenville and Sanford Dams. May 2022.
[94] Michigan Dam Safety Task Force Report. February 12, 2021.
[95] Research into EGLE's dam database suggests that many of the records for non-high-hazard dams are incomplete and may not be reliable.

project includes a research component: installation of FishPass, a fish-sorting device that will help researchers understand how to manage invasive species in the Great Lakes watershed.[96] In 2023, EGLE granted $15.3 million for dam removal and repair projects.[97]

Michigan also has a number of flood-control levees. The U.S. Army Corps of Engineers Levee Database lists 55 levee systems in Michigan (102 miles).[98] It is unclear how complete this information is. Most levees are owned and operated by local entities (counties and municipalities). The condition and capacity of the levees are known to be deficient in some areas, such as the Jefferson-Chalmers neighborhood of Detroit.[99,100] Research was unable to identify data that would permit a more thorough analysis.

Great Lakes Water Authority

The metro-Detroit Great Lakes Water Authority (GLWA) service area is particularly notable, and worth individual attention as a focus of state water infrastructure policy. A 2018 SEMCOG area water resources plan states that GLWA provides drinking water to 127 communities, containing about 40 percent of the population of the state of Michigan.[101]

The Great Lakes Water Authority provides water infrastructure to about 40% of Michigan residents.

GLWA also provides sanitary and combined stormwater/sanitary sewer treatment for much of southeast Michigan. The GLWA wastewater treatment plant was placed into service in 1940, connected to a sewer system that dates back to the 1836 encapsulation of Savoyard Creek to create the "Detroit Grand Sewer."[102] The Detroit sewer system has since expanded to serve Detroit and multiple partner municipalities in Southeast Michigan, representing nearly a third of Michigan's population.[103] GLWA estimates that over 24,000 miles of sewers ultimately flow to the wastewater treatment plant.[104,105] This expansion was intended to decrease costs by leveraging existing infrastructure to facilitate suburban development. However, this has challenged the capacity of the sewer system in older (downstream) areas of the network.

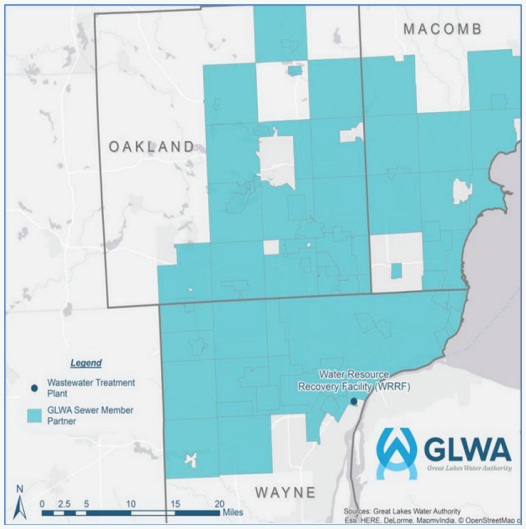
From the 2020 GLWA Wastewater Treatment Plan: "Since 1970 … the GLWA service area quadrupled in size to 944 square miles as the population moved from urban to suburban areas. The total population of southeast Michigan stayed approximately the same, but suburban development exploded. Rural and agricultural land uses were transformed into residential, commercial, and industrial uses, resulting in vastly expanded wastewater collection systems to serve population shifts and increased stormwater runoff from impervious areas."[106]

The combined factors of land use changes and aging infrastructure have put increasing pressure on sewer systems in Southeast Michigan. This has been obvious in recent years as both overall precipitation and extreme precipitation events have increased. The GLWA wastewater treatment plant is the largest in the United States, and yet the coverage area has been subject to multiple floods and recurring basement backups.

The region is struggling with a backlog of maintenance and replacement projects, yet must often install new infrastructure to accommodate new developments on the urban periphery. This dynamic has created chronic underfunding with no obvious solutions. Bringing Michigan's water infrastructure into a state of good repair will require decades of strategic planning and investment.

[96] Great Lakes Fisheries Commission. FishPass.
[97] Garrett Ellison. " 16 Dam removal, repair projects split $15.3M in grants." MLive. May 18, 2023.
[98] USACE National Levee Database.
[99] Aaron Mondry. "Will the city's plans save the canal district or destroy what makes it unique?" Outlier Media. July 27, 2022.
[100] USACE – Detroit District. Lake St Clair Flood Risk Reduction Study For the Jefferson-Chalmers Neighborhood, Detroit, Michigan. July 2022.
[101] https://www.glwater.org/members/member-partners/
[102] Detroit Water and Sewerage Department. "Wet Weather Pollution Information Kit." October 2002.
[103] https://www.glwater.org/members/member-partners/
[104] Great Lakes Water Authority. Waste Water Master Plan. 2020. P. 1-8 (pdf p. 22)
[105] Not all drinking water customers of GLWA are sewer customers, hence the difference in population served.
[106] CDM Smith. Great Lakes Water Authority Wastewater Master Plan. 2020

Figure 6: Great Lakes Water Authority Sanitary Sewer Service Area



Source: Great Lakes Water Authority. Waste Water Master Plan. 2020. P. 1-8 (pdf p.22)

Energy Infrastructure

As with other infrastructure systems, Michigan's energy infrastructure is challenged by age, inefficient land use patterns, and maintenance backlogs. Many areas of Michigan are subject to frequent power losses in the aftermath of storms. Michigan's Public Services Commission and utility companies are working to address system deficiencies while transitioning to renewable energy.[107] Simultaneously addressing reliability, cost, and climate issues with energy policy is a complex problem that is not yet well understood.[108]

MI Healthy Climate Plan aims to reduce greenhouse gas (GHG) emissions 28 percent below the 2005 levels by 2025 and achieve carbon neutrality by 2050. In 2005, Michigan's energy sector output 75.6 million metric tons (MMT) of carbon emissions. By 2018, this had been reduced to 58.9 MMT, already a 22 percent reduction. This reduction occurred entirely due to a transition from coal to natural gas (methane) for electric power generation.[109]

Additionally, there are significant emissions related to natural gas supplied directly to residential, commercial, and industrial buildings. Michigan usually ranks in the top five states for residential use of natural gas in a year. Over 75 percent of Michigan homes use natural gas as the primary heating fuel. Michigan is also the nation's foremost user of propane for residential heating.[110] Michigan's energy sector has become extremely reliant on natural gas and propane. To achieve deep decarbonization of power, this network would have to be abandoned or converted to some kind of net-zero gaseous fuel.[111]

Michigan is highly reliant on fossil gas for electricity generation and residential heating.

Further reductions are forthcoming as coal power generation is phased out. Yet, a power generation system based on natural gas still has substantial carbon emissions, as well as direct methane emissions from leakage (methane is a powerful greenhouse gas itself).[112]

[107] https://www.michigan.gov/mpsc/commission/workgroups/mi-power-grid/phase-iii-integrated-resource-plan-mirpp-filing-requirements-demand-response-study-energy-waste-red
[108] Devonie McCamey. "What We Know—and Do Not Know—About Achieving a National-Scale 100% Renewable Electric Grid." NREL. May 19, 2021.
[109] Michigan Council on Climate Solutions: Energy Production, Transmission, Distribution, and Storage Workgroup Recommendations. October 2021.
[110] U.S. Energy Information Administration (EIA). Michigan State Energy Profile.
[111] Michigan Council on Climate Solutions: Energy Production, Transmission, Distribution, and Storage Workgroup Recommendations. October 2021.
[112] UN Environment Programme. "How secretive methane leaks are driving climate change." July 19, 2022.

Unless Michigan strongly embraces constructing new nuclear power generation facilities[113], approaching a carbon-neutral power sector will require total reliance on renewable generation and significant storage capacity; basically, an entire re-engineering of the electric grid.[114] It is not clear how this can be done.[115] That does not imply it cannot be done—but there is not yet a coherent plan or much understanding of what a future renewables-based Michigan grid looks like or how it operates.

Transitioning the grid must not impose affordability constraints. In April 2023, the most recent available month of data, Michigan residential electricity prices were 13.3 percent above the national average. This is tempered by Michigan's natural gas prices, which were 20.4% less than the national average (**Table 7**). Decarbonizing the energy sector implies relying less on natural gas both for direct consumption and as a feedstock for electricity generation. It will be difficult to accomplish this without raising costs.

Table 7: States Ranked by Average Residential Electricity Price and Average Residential Total Energy Price (2021 Data)

Residential Electricity Price			Residential Total Energy Price		
Rank	**State**	**$/million BTU**	**Rank**	**State**	**$/million BTU**
1	Washington	29.63	1	Utah	15.98
2	Idaho	29.77	2	Idaho	18.38
3	Utah	30.57	***3***	***Illinois***	***18.38***
4	Nebraska	31.51	4	Colorado	18.56
5	North Dakota	31.79	5	Montana	19.20
6	Oklahoma	32.24	6	Wyoming	19.47
7	Louisiana	32.30	7	Nebraska	19.74
8	***Tennessee***	***32.44***	***8***	***Minnesota***	***20.20***
9	Wyoming	32.74	***9***	***MICHIGAN***	***20.62***
10	Montana	32.89	***10***	***Ohio***	***20.78***
14	***Missouri***	***33.46***	***11***	***Wisconsin***	***20.87***
16	***Kentucky***	***33.71***	***12***	***Iowa***	***21.01***
26	***Iowa***	***37.30***	***20***	***Missouri***	***22.65***
27	***Ohio***	***37.42***	***21***	***Indiana***	***22.79***
33	***Illinois***	***38.61***			
34	***Indiana***	***39.20***	**United States**		**24.45**
35	***Minnesota***	***39.57***			
			24	***Pennsylvania***	***23.46***
United States		**40.03**	***28***	***Tennessee***	***24.71***
			30	***Kentucky***	***25.60***
37	***Pennsylvania***	***40.33***			
38	***Wisconsin***	***42.56***	41	Texas	29.07
			42	Massachusetts	29.53
41	***MICHIGAN***	***51.39***	43	New Hampshire	29.94
42	Vermont	56.44	44	Connecticut	30.81
43	New York	57.10	45	Arizona	31.21
44	New Hampshire	58.18	46	South Carolina	31.88
45	Connecticut	64.21	47	Alabama	32.33
46	Rhode Island	65.36	48	Florida	34.41
47	Alaska	66.09	49	California	35.69
48	California	66.89	50	Hawaii	92.97
49	Massachusetts	67.09			
50	Hawaii	98.16			

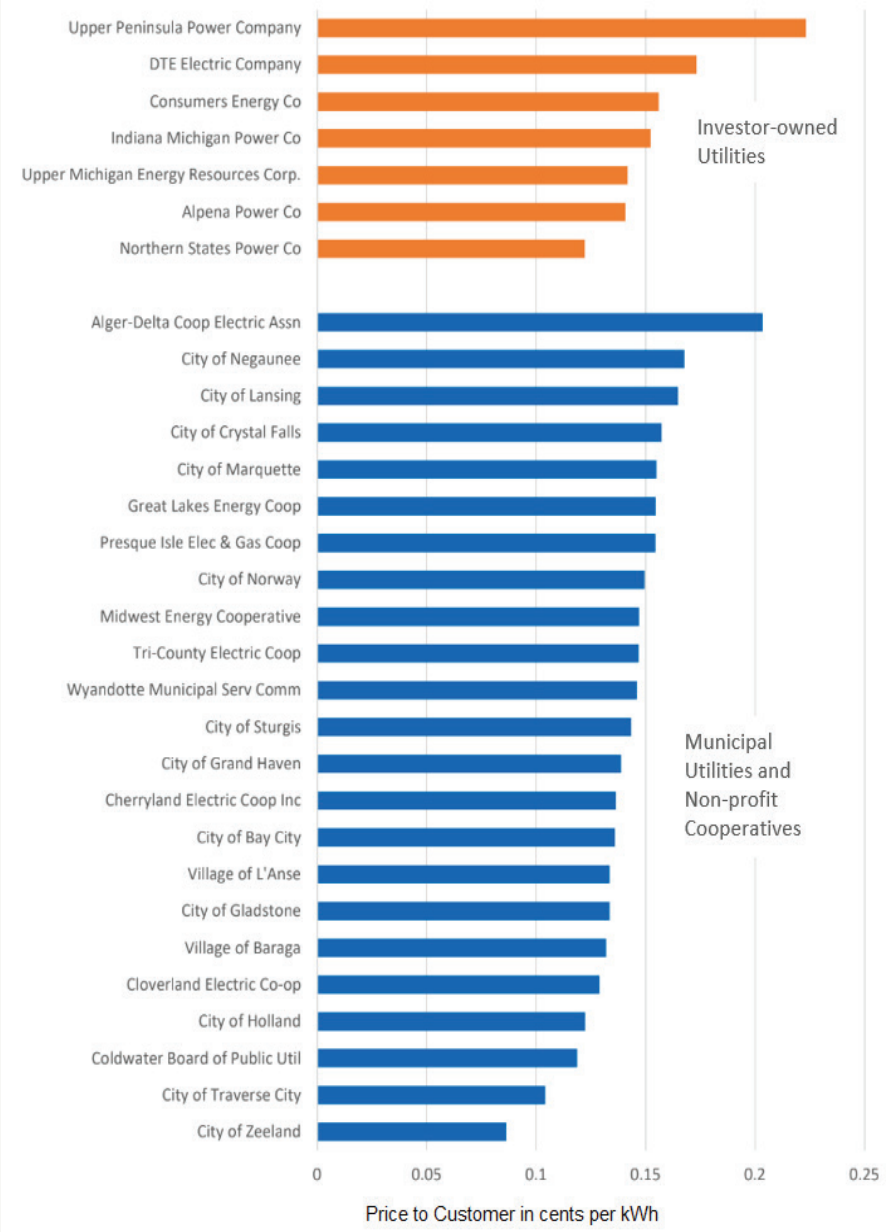
Note: Total Energy Price includes electricity, natural gas, wood, and petroleum-derived fuels

Source: U.S. Energy Information Administration, State Energy Data System, Table E3

[113] Molly Samuel. Study: US Unlikely To See New Nuclear Power Anytime Soon." WABE. July 25, 2018.
[114] Michigan Council on Climate Solutions: Energy Production, Transmission, Distribution, and Storage Workgroup Recommendations. October 2021.
[115] Devonie McCamey. "What We Know—and Do Not Know—About Achieving a National-Scale 100% Renewable Electric Grid." National Renewable energy Laboratory (NREL). May 19, 2021.

While the state of Michigan has overall above average electricity costs, this varies substantially by provider. Residential electricity costs vary from about 9 cents per kWh for the City of Zeeland municipal utility to just over 22 cents per kWh for the Upper Peninsula Power Company. Most utilities in Michigan have residential electricity costs falling in a narrow range between 13 and 17 cents per kWh (**Figure 7**).

Figure 7: Cost of Residential Electric Service in cents per kWh for all Michigan Providers



Source: Citizens Utility Board of Michigan (2022)

Table 8: States Ranked by Percentage of Electricity Generation from Renewable Resources (2020 Data)

Rank	State	% Renewable
1	***Iowa***	***62.5%***
2	South Dakota	53.8%
3	Vermont	50.5%
4	Kansas	46.6%
5	Oklahoma	44.5%
6	Maine	42.2%
7	New Mexico	40.5%
8	North Dakota	37.2%
9	California	34.7%
10	Colorado	33.8%
13	***Minnesota***	***28.3%***
21	***Illinois***	***13.0%***
23	***Indiana***	***11.4%***
25	***MICHIGAN***	***10.2%***
Median State		**10.1%**
27	***Missouri***	***9.8%***
34	***Wisconsin***	***6.1%***
40	***Ohio***	***3.3%***
41	Delaware	2.8%
42	Alabama	2.7%
43	Alaska	2.7%
44	Mississippi	2.7%
45	Connecticut	2.6%
46	Arkansas	2.5%
47	***Pennsylvania***	***2.4%***
48	Louisiana	2.2%
49	***Tennessee***	***1.7%***
50	***Kentucky***	***0.7%***

Note: Includes solar, wind, geothermal, and biomass. Does not include hydroelectric.

Source: The Motley Fool using U.S. Energy Information Agency Data, 2022.

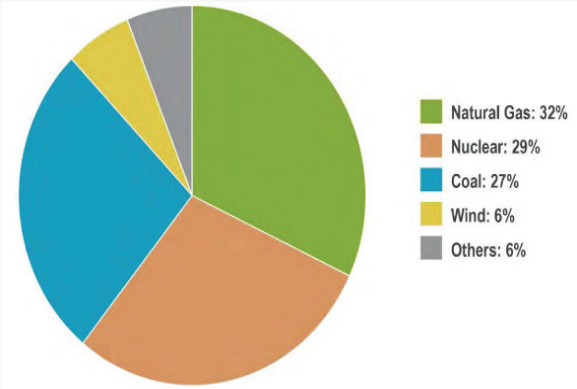
Michigan is neither an especially sunny or windy state. This does not mean that Michigan cannot build a grid built on renewables, but it complicates things. All else being equal, compared to most regions, Michigan will need to dedicate more land to solar and wind generation to get an equivalent amount of power.

As of 2020, Michigan's percentage of electric power generation that comes from renewable resources (not including nuclear or hydroelectric) is a bit over 10 percent. This is about equal to the median state (**Table 8**).

As of 2021, the most recent available data, renewable energy makes up about 11 percent of Michigan's electricity production. The transition to renewable energy includes replacing large centrally-located power plants with many smaller distributed solar and wind farms. This implies that new transmission lines will have to be routed to move electricity from where it is generated to where it is used. The cost and approach to accomplish this is yet unknown. Michigan will need to find places to install renewable generation, storage facilities, and run new transmission lines. Michigan's sprawling low-density land use will make this difficult. In addition to engineering and construction costs, acquiring real estate or rights-of-way is likely to be arduous and expensive.

Unlike water and transportation infrastructure, much of the power grid is not public infrastructure. Power generation, transmission, and grid operation is controlled by a wide range of private companies and cooperatives under government regulation. This limits the ability of public officials to drive changes. Increased demand for electricity, including from electric vehicles (EVs), complicate efforts to reduce carbon footprint of Michigan's electric grid.[116]

Figure 8: Michigan Electric Generation by Source (2021 Data)



Source: MI Healthy Climate Plan (2022)

[116] Lou Blouin. "We're not ready for the electrification era." University of Michigan Dearborn. March 8, 2023.

Michigan has a head-start on many states in focusing attention on building a modern, resilient electric grid for a low-emissions future. In late 2016, Michigan passed legislation requiring electricity providers to meet a 12.5 percent renewable portfolio standard by 2019 and 15 percent by 2021 and an energy optimization goal of meeting at least 35 percent of the state's electric needs through energy waste reduction and renewable energy by 2025. The Michigan energy legislation also requires periodic submittal of an Integrated Resource Plan (IRP) to the Michigan Public Service Commission.[117]

The MI Healthy Climate Plan includes an initiative to increase the percentage of Michigan's electricity generated from renewable resources from 11 percent in 2021 to 50 percent by 2030.[118] To get a sense of the scale of investment and effort that will be required, we can assume a scenario whereby Michigan power utilities will meet future generation capacity demand with 50 percent wind and 50 percent solar. Assuming an average capacity of 3MW per wind turbine, Michigan will need to add about 213 new turbines each year from 2023 to 2030. Solar module capacity spans a much larger range than wind turbines. DTE's largest solar farm in Lapeer (featured in banner image), for example, has 45MW of capacity on 250 acres. Opened in 2017, this averages 0.18MW per acre. Consumers Energy has 4.5MW of capacity on 28.27 acres at its three Solar Garden sites. The last of these sites came online in 2021, averaging 0.16MW per acre. Using such figures as a baseline, Michigan will need to establish around 3,750 acres of solar each year between now and 2030.[119]

Society has come to rely on a stable power supply at a reasonable cost. The cost to install renewable power generation capacity is now competitive with fossil fuel generation on a kWh basis, but this is not the only consideration. There are physical limitations to how much renewable energy the grid can accommodate due to the sporadic nature of renewables generation. Complicated engineering solutions will be required to transition to affordable renewable energy without compromising service.[120]

Michigan will be uniquely challenged to transition to renewable energy without sacrificing reliability. Disruptive storms frequently impose extended electric power outages across the state. Michigan ranks in the bottom ten among states for electric service reliability, and below all peer states (**Table 9**).

There is unique potential for offshore wind along Great Lakes coastlines (though it is unclear if offshore wind is an optimal approach to meeting goals).[121,122]

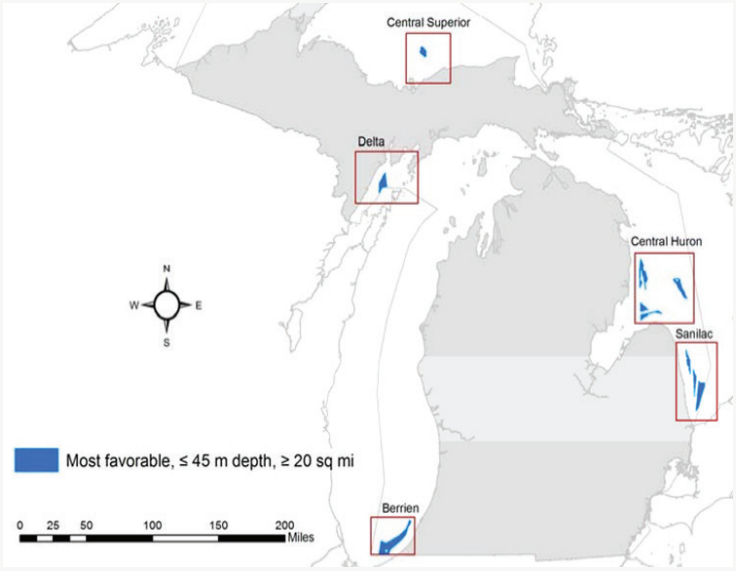
Table 9: Electric Service Reliability Ranking

State	Electric Service Reliability Rank
Nevada	1
Arizona	2
Nebraska	3
Delaware	4
Illinois	5
Florida	6
North Dakota	7
Iowa	***8***
Minnesota	***9***
Missouri	***10***
Wisconsin	***29***
Pennsylvania	***31***
Kentucky	***32***
Tennessee	***37***
Indiana	***38***
Ohio	***40***
Oklahoma	41
New Hampshire	42
Virginia	43
Vermont	44
MICHIGAN	***45***
Mississippi	46
Arkansas	47
Louisiana	48
Maine	49
West Virginia	50

Source: Citizens Utility Board (2021)

[117] DTE Energy. Climate Change Disclosure Financial Statement to CDP. 2021.
[118] EGLE. MI Healthy Climate Plan. 2022.
[119] Kala Sperbeck and Eric Paul Dennis. "Meeting Michigan's Renewable Energy Goals will Require Substantial Investment and Sustained Effort." Citizens Research Council of Michigan. February 6, 2023.
[120] Scott Disavino. "U.S. Midwest in danger of rotating power blackouts this summer." Reuters. June 3, 2022.
[121] Taylor Haelterman. "Offshore wind could provide double the electricity Michiganders used in 2019." Great Lakes Echo. May 11, 2021.
[122] Michael Kleplinger and Public Sector Consultants. "Report of the Michigan Great Lakes Wind Council." October 1, 2010.

Figure 9: The Most Favorable Areas for Offshore Wind Power Generation in Michigan



Source: Michael Kleplinger and Public Sector Consultants. "Report of the Michigan Great Lakes Wind Council." October 1, 2010.

As Michigan utilities plan, engineer, and construct the next-generation electric grid, it must be made more dependable. Power lines could be buried underground in shared utility corridors to achieve aesthetic benefit and avoidance of power-outages by storm damage. This approach is more effective than tree-trimming programs, but also significantly more costly, at least under current funding and regulatory schemes. A broad program of power line undergrounding would require a paradigm shift in how electric power infrastructure is planned and regulated.[123]

It will be a significant challenge to address all of Michigan's energy-related policy goals. Accommodating additional electricity demand while maintaining cost and reliability, all while reducing GHG emissions, is a wicked problem with no clear solution. It will be necessary to maintain a realistic perspective on what is achievable and balance trade-offs when pursuing energy policy.

Telecommunications Infrastructure (Broadband)

Broadband is defined by the Federal Communications Commission (FCC) as an internet connection with download speeds of at least 25 megabits per second (Mbps) and upload speeds of at least 3 Mbps (25/3 Mbps).[124] This is sufficient for most uses, including streaming hi-def video and video conference calling. Higher speeds are usually needed only if multiple users simultaneously require high data-transfer speeds over the same account.

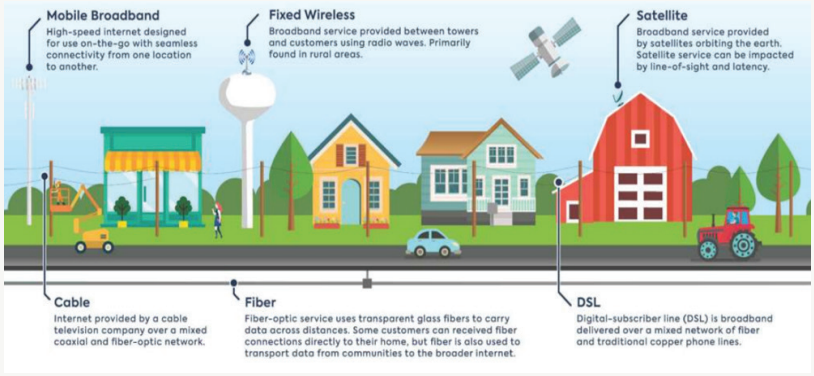
Broadband: Internet service with minimum 25/3 Mbps download/ upload speeds.

***High-speed* Broadband:** Internet service with minimum 100/20 Mbps download/ upload speeds.

Technically, broadband internet is universally available throughout Michigan and the United States. Even a tiny island in the middle of Lake Superior can receive broadband internet service via a subscription to a satellite broadband service provider.[125] Further, most residents who have a phone line have access to digital subscriber line (DSL) internet, which is often available at broadband speed, though not high-speed broadband.

[123] Eric Paul Dennis. "Legislative Direction is Needed to Facilitate Infrastructure Coordination." Citizens Research Council of Michigan. June 21, 2023.
[124] NTIA. Broadband Glossary.
[125] Trey Paul. "Best Satellite Internet Providers of 2023."

Figure 10: Broadband Can be Delivered Over Several Network Types



Source: Michigan Broadband Roadmap.

Broadband deployment has been a federal, state, and private sector priority for several years. Michigan now has practically universal broadband coverage with 100 percent of the state having access to service with at least 25/3 Mbps speed. Further, the FCC estimates that over 90 percent of units (service addresses) have access to high-speed broadband of 100/20 Mbps. Eighty-six percent of units have access to even higher speeds of at least 250/25 Mbps.[126]

This contradicts conventional wisdom. It is often said that many of Michigan's rural residents are "unserved" by broadband internet.[127] However, such statements require a very narrow definition of broadband. Because satellite broadband service is subject to occasional interruption and latency issues, regulatory frameworks established by the Federal Communications Commission (FCC), U.S. Commerce Department, and the State of Michigan, designate areas served only by satellite broadband as "unserved." In addition, areas also served by fixed wireless broadband service provided over unlicensed airwaves are considered unserved due to the possibility of interference. In other words, discussions about areas "unserved by broadband internet," use regulatory definitions, not literal service availability (which is practically universal).

A state-by-state ranking from a research organization called BroadbandNow puts Michigan about middle-of-the-pack, both nationwide and among peer states (Table 10).

It was proposed in both the 21st Century Infrastructure Commission Report (2016) and the "Michigan Broadband Roadmap"128 (2018) that the state would benefit from establishing a single point-of-contact to help both Michiganders seeking internet service and Internet Service Providers (ISPs) seeking to provide it. In response, the Michigan High-speed Internet Office (MI-HI) was created.[129]

MI-HI has since updated the Michigan Broadband Roadmap, establishing a goal to provide 'high-speed' broadband to everyone in the state. Strategies include subsidies to ISPs to build-out their networks and 'dig once' policies that would reduce installation costs of fiber in road ROWs. MI-HI works with MEDC to administer supporting grants.[130]

MI-HI has defined "unserved" areas as those lacking high-speed broadband of 100/20 Mbps speeds.[131] Thus, many areas with broadband access (at least 25/3) are nevertheless defined as unserved by Michigan. MI-HI states that the reason for adopting this definition is "federal and state funding programs' usage of a similar speed of 100/20 Mbps as the unserved standard."[132] This is not entirely accurate; federal programs (e.g., BEAD) define areas with between 25/3 and 100/20 Mbps speeds as "underserved," not unserved.[133]

[126] FCC National Broadband Map
[127] Tracy Samilton. "Michigan on cusp of major broadband expansion to areas of state with little access." NPR. April 17, 2022.
[128]Michigan Office of High Speed Internet. 2021 Update to the Michigan Broadband Roadmap. November 2021.
[129] https://www.michigan.gov/leo/bureaus-agencies/mihi
[130] Michigan Department of Labor and Economic Opportunity. 2021 Update to the Michigan Broadband Roadmap. 2021.
[131] LEO/MI-HI, Robin Program Fact Sheet
[132] Michigan Department of Labor and Economic Opportunity, Office of High-Speed Internet. Michigan Broadband Roadmap, 2021 update.
[133] National Telecommunications and Information Agency (NTIA), U.S. Dept of Commerce. Notice of Funding Opportunity (NOFO). Broadband Equity, Access, and Deployment Program.

Table 10: BroadbandNow Rankings of Statewide Broadband Service

Rank	State	Wired/Fixed Wireless Broadband (%)	Wired Low-Priced Broadband (%)	Fiber-Optic Service (%)	Median Download Speed (Mbps)	Median Upload Speed (Mbps)
1	Maryland	97.0	34.8	63.8	88.4	21.2
2	New Jersey	98.5	18.8	69.7	89.2	23.3
3	New York	98.8	18.8	65.7	88.5	21.2
4	Delaware	97.3	15.4	57.8	92.5	20.5
5	Washington	96.7	54.2	45.2	58.2	10.2
6	South Carolina	94.3	31.0	38.0	43.7	30.6
7	Virginia	93.6	19.0	56.3	84.3	19.5
8	Oregon	94.8	44.0	53.8	75.8	11.7
9	Massachusetts	98.3	19.0	45.9	63.0	21.1
10	***Illinois***	***95.7***	***24.1***	***29.3***	***85.1***	***15.2***
17	***Pennsylvania***	***96.1***	***18.8***	***48.2***	***77.7***	***16.9***
22	***Tennessee***	***95.1***	***31.0***	***54.0***	***73.4***	***12.3***
24	***Indiana***	***92.3***	***23.1***	***41.9***	***59.0***	***13.1***
31	***MICHIGAN***	***93.5***	***23.1***	***47.8***	***66.3***	***11.1***
32	***Iowa***	***94.8***	***15.4***	***48.8***	***60.9***	***14.3***
36	***Kentucky***	***93.7***	***14.3***	***51.9***	***73.9***	***11.4***
37	***Ohio***	***95.8***	***22.6***	***30.1***	***52.2***	***11.6***
38	***Minnesota***	***95.6***	***11.1***	***38.1***	***64.3***	***11.2***
41	***Wisconsin***	***93.5***	***14.3***	***25.5***	***61.9***	***11.2***
42	Maine	97.2	20.0	10.6	53.7	9.2
43	Oklahoma	82.3	25.0	31.3	58.3	10.7
44	New Mexico	88.8	11.1	21.4	55.4	13.1
45	***Missouri***	***86.9***	***15.4***	***38.1***	***49.8***	***11.1***
46	Vermont	94.6	11.1	31.2	50.6	11.2
47	Arkansas	77.5	24.1	33.2	51.9	10.3
48	Mississippi	79.9	14.3	25.0	45.6	11.0
49	Alaska	86.6	0.0	11.1	38.2	7.6
50	West Virginia	65.8	11.1	5.5	51.3	9.0

Rankings are based on access to broadband internet - including access to low price plans and fiber-optics - and the quality of their internet.

Source: BroadbandNow Research (2023)

The federal definition of broadband internet has been updated in the past, and may be updated again in the near future. The 25/3 standard was adopted in 2015. In July of 2023, the Chair of the Federal Communications Commission proposed that these speeds were no longer sufficient, and announced an effort to evaluate raising the standard to 100/20.[134]

Federal Broadband Equity, Access, and Deployment (BEAD) Program

The federal Bipartisan Infrastructure Law has made billions of dollars of subsidies available to build-out broadband networks. Both unserved and underserved areas are eligible for federal funding. Only providers services offering 100/20 speeds over wired or licensed fixed wireless networks will be eligible for federal subsidies for service expansion.[135] The BEAD program emphasizes the build-out of fiber-to-the-premises (FTTP) networks, which is relatively costly, but considered the highest-quality type of internet access.

MI-HI encouraged Michiganders who are in underserved areas to assure that they are being counted in the FCC's broadband map.[136] The FCC map has now been updated to reflect the nationwide challenge process, and the NTIA will be using those results to distribute BEAD money via a block grant program. Michigan is estimated to have 127,595 underserved and 315,620 unserved addresses. [137]

[134] FCC News. Chairwoman Rosenworcel Proposes National Goal of 100% Access to Affordable Broadband. July 25, 2023.
[135] NOFO: BEAD Program.
[136] Todd Spangler. "No broadband available at your home or business? You better tell the feds, quick." Detroit Free Press. Dec 1, 2022.
[137] FCC broadband data via Mike Conlow

Considering this data with respect to population can provide a rough idea of what proportion of a state's residents, comparatively, have been designated as unserved for purposes of BEAD funding. By this measure, Michigan ranks below most peer states, though above Wisconsin, Missouri, and Kentucky.[138]

Table 11: Michigan and Peer States, Unserved Locations and Available BEAD Funding, Ordered by Unserved Locations per 100 Population

State	Unserved Locations	BEAD Funding Available	Population (2022)	Unserved Locations per 100 Residents
Ohio	181,604	$825,689,893	11,756,058	1.54
Illinois	234,649	$1,182,969,455	12,582,032	1.86
Pennsylvania	279,085	$1,226,477,794	12,972,008	2.15
Minnesota	134,850	$689,027,273	5,717,184	2.36
Iowa	84,097	$435,155,547	3,200,517	2.63
Tennessee	188,814	$859,477,962	7,051,339	2.68
Indiana	198,081	$916,251,507	6,833,037	2.90
MICHIGAN	315,620	$1,418,015,799	10,034,113	3.15
Wisconsin	246,113	$1,152,512,901	5,892,539	4.18
Missouri	337,004	$1,830,620,778	6,177,957	5.45
Kentucky	258,435	$1,201,187,217	4,512,310	5.73

Source: Mike Conlow

Multiple stakeholders contend that the FCC's methodology in developing and updating the broadband coverage map is inaccurate or unfair in various ways.[139] Regardless, the process has been completed and Michigan is slated to receive about $1.4 billion to subsidize the deployment of high-speed broadband internet service to unserved and underserved areas. MI-HI is now in the process of drafting an action plan as required to receive BEAD funding.

Michigan should have ample resources through the BEAD program to assure that all public institutions (e.g., schools, libraries, government/tribal facilities) have access to dependable high-speed broadband internet. This funding can further be used to expand infrastructure into residential rural areas. One concern is that broadband providers will require perpetual public subsidies to maintain the sprawling fiber infrastructure that is now being built-out in rural areas.

Both state and federal broadband subsidies emphasize providing widespread fiber-to-the-premises (FTTP) broadband. This emphasis does not appear justified by benefit-cost considerations.[140] Michigan is estimated to have about 315,620 addresses that are "unserved" by wire-line broadband or fixed wireless broadband on a licensed signal. From the BEAD program alone, Michigan is slated to receive about $1.4 billion. This equates to about $4,500 for each unserved location.[141] All locations designated as "unserved" have access to satellite broadband. Simply giving each "unserved" location the equivalent $4,500 subsidy would cover a subscription to satellite broadband for several years.[142] Many of these "unserved" locations have additional, low-cost, internet options such as unlicensed fixed wireless broadband and digital subscriber lines (DSL) over copper.

MI-HI should look for opportunities to embed performance-based standards into subsidies going to broadband network deployment. In designing the BEAD action plan, Michigan should set a reasonable "Extremely High Cost per Location Threshold" to minimize the market distortions created by BEAD's non-technology-neutral approach that precludes unlicensed fixed wireless broadband service.[143]

[138] This should not be interpreted as a percentage of state populations unserved. However, assuming that broadband serviceable locations are identified relatively consistently between states, this metric should provide a comparative measure for which states have more, or less, of their population served by qualifying broadband services for the purposes of BEAD grant funding.
[139] Mike Conlow. "The state that lost its chair after the music stopped." Mikes Newsletter (Substack.) May 31, 2023.
[140] William Lehr, PhD. "Getting to the Broadband Future Efficiently with BEAD Funding." Massachusetts Institute of Technology, Benton Institute for Broadband & Society. February 10, 2023.
[141] FCC broadband data via Mike Conlow
[142] HughesNet home page. As of July 2023, HughesNet offers satellite broadband plans starting at $600/year.
[143] William Lehr, PhD. "Getting to the Broadband Future Efficiently with BEAD Funding." Massachusetts Institute of Technology, Benton Institute for Broadband & Society. February 10, 2023.

Affordability and Equity

Having universal coverage does not necessarily imply that services are equitable or affordable. Michigan is continuing to expand fixed broadband networks, which will increase access to higher-speed broadband services and may drive down costs by giving customers more options.[144] The residual issues with internet access are primarily due to cost burden on low-income customers.[145,146]

Having universal coverage doesn't necessarily imply that services are equitable or affordable.

An additional issue is that many residents, particularly older people, may lack digital literacy. This is becoming a larger problem as more and more essential services are becoming accessible only online.[147]

Several municipalities have considered investing in broadband networks but been stymied by state policy.[148] Public broadband provision may be a solution to accessibility, affordability, and equity issues. Ohio, which is estimated to have the fewest unserved locations per 100 population (Table 11), has provided broadband to many rural communities through municipal providers.[149,150]

Infrastructure Coordination

This paper has distinguished infrastructure into four types: transportation, water, energy, and telecommunications. These distinctions make sense because these various infrastructure types are typically planned and operated independently. However, this approach does not incorporate the relationships and interdependencies that each infrastructure component has on each other, as well as on overall land use patterns.

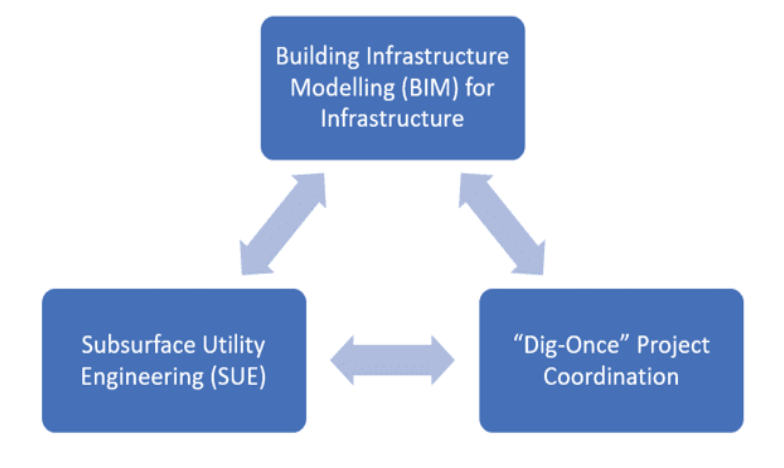
New technologies provide opportunities to more efficiently manage infrastructure assets in a variety of ways. But utilizing such technologies will require ROW users to invest in institutional changes that impact their fundamental business practices. Most agencies are adopting new technologies for their own purposes. However, if each individual agency invests in technology solutions without consideration of how their digital platform can share data with other ROW users, Michigan will miss opportunities to enable meaningful collaboration between agencies.

The state government is positioned to establish a framework by which infrastructure with public ROWs is planned, designed, constructed, and managed as a coherent engineered system. Such a framework would reduce costs for all ROW users and improve the condition and performance of infrastructure. This would be a paradigm shift in infrastructure management, but a necessary investment to obtain a fiscally sustainable program of infrastructure management.

Efficient coordination requires that all ROW users have a shared vision for how the ROW could be managed as a coherent engineered system; this is the function of Building Information Modelling (BIM) for infrastructure. Obtaining that information requires establishing and recording where underground utilities are located; this is the function of Subsurface Utility Engineering (SUE). Once ROW users obtain a shared vision and accurate data, they will be better enabled to share resources and reduce costs through collaborative construction projects; this is the objective of dig-once construction.[151]

[144] Melissa Nann Burke. " Michigan to Receive $250M for Broadband Expansion Work." The Detroit News via govtech. October 7, 2022.
[145] Erika Geiss. "OPINION: Detroit has a new redlining problem: Digital redlining." Bridge Michigan. July 27, 2022.
[146] David Lewis. "OPINION: AT&T isn't 'digital redlining' Detroit — we're expanding access." Bridge Michigan. August 4, 2022.
[147] Dana Afana. "The world is going virtual but many in Detroit are still left behind." Detroit Free Press. October 2, 2021.
[148] Sean Gonsalves. "Michigan Moves to Limit Federal Funds for Municipal Broadband." April 6, 2022.
[149] Jon Brodkin. "Ohio GOP ends attempt to ban municipal broadband after protest from residents." Ars Technica. June 29, 2021.
[150] Nick Evans. "Local leaders launch Broadband Access Ohio to advocate for municipal broadband services." Ohio Capital Journal. February 17, 2022.
[151] Eric Paul Dennis. "Legislative Direction is Needed to Facilitate Infrastructure Coordination." Citizens Research Council of Michigan. June 21, 2023

Figure 11: BIM, SUE, and dig-once construction can be combined to reduce costs and improve infrastructure quality.



Source: Citizens Research Council of Michigan

Summary and Discussion

It is difficult to provide a clear and coherent description of infrastructure across Michigan. However, available data suggests Michigan generally underperforms peer states. Further, the United States typically has overall poor infrastructure compared to peer nations. Clearly, there is room to improve.

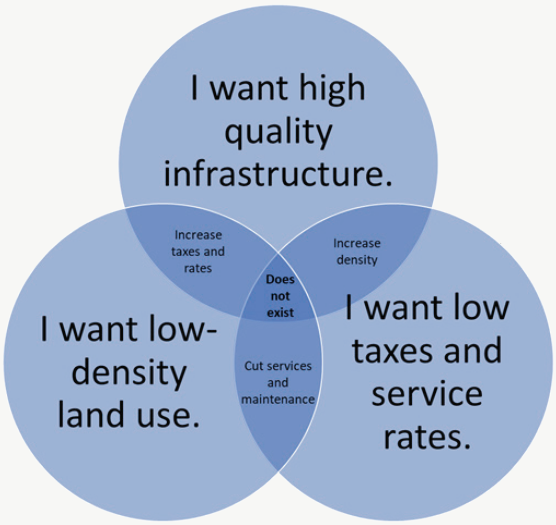
A critical reason that both the U.S. and Michigan struggle to maintain infrastructure in good repair relates to the built environment and population distribution. It is expensive and inefficient to provide infrastructure to low-density population areas. The United States and Michigan embraced suburban low-density development following World War II, as imagined and promoted by the automotive industry, petroleum industry, and highway construction industry.[152] Henry Ford proposed, "We shall solve the problems of the city by leaving the city."

Michigan was on the forefront of a societal experiment in suburbanization. In the early twentieth century, Detroit was a world class city with vast bicycle facilities[153] and the world's largest public electric streetcar network.[154] By the mid twentieth century, federal, state, and local policies were aligned to reconfigure cities into sprawling metropolitan areas with expansive growing suburbs. These policies put increasing social and economic pressure on existing cities. High speed freeways and boulevards were constructed in established urban neighborhoods, bringing traffic, noise, pollution, and generally making cities undesirable places to live.

This suburban experiment ran into a scaling problem. As urban populations became increasingly dispersed into suburbs, ever wider highways and roads were needed to accommodate the vehicle traffic. The widened highways encouraged growth in exurban communities now perceived as within commuting distance to employment and commercial centers in central business districts. As businesses and commercial investments made location decisions, it often made sense to follow the residential population to low-density development on the urban periphery. Over a single generation, the traditional urban form of cities was upended to accommodate automobile travel. This made life without an automobile difficult whether one lived in a city or otherwise. Henry Ford once bragged, "we took what was a luxury and turned it into a necessity."

[152] Peter Norton. Fighting Traffic: The Dawn of the Motor Age in the American City. MIT Press. 2011.
[153] Guide Map of the City of Detroit for Bicyclists (1896).
[154] Samantha Keene. "Detroit's Streetcars: Past and Present. Detroit Historical Society. July 18, 2016.

Figure 12: There are trade-offs between infrastructure quality, costs, and land use.



Source: Strongtowns.org, modified by Citizens Research Council of Michigan

The United States has never adopted a coherent approach to land use planning, nor have individual states, including Michigan. Without a strategic approach to land use, highway departments became the most powerful land use planners in the nation. For decades, transportation planning has centered around an automotive-centric approach that emphasizes moving vehicles as quickly as possible. Neighborhoods with wide high-speed streets are undesirable for many residents. As highways and streets in older neighborhoods are expanded to accommodate more traffic, many people move out of these neighborhoods in search of quieter, safer areas. In Michigan, a state with a stable population, the expansion of road infrastructure has meant that the same number of people are responsible for an ever-increasing amount of pavement and other roadway infrastructure.

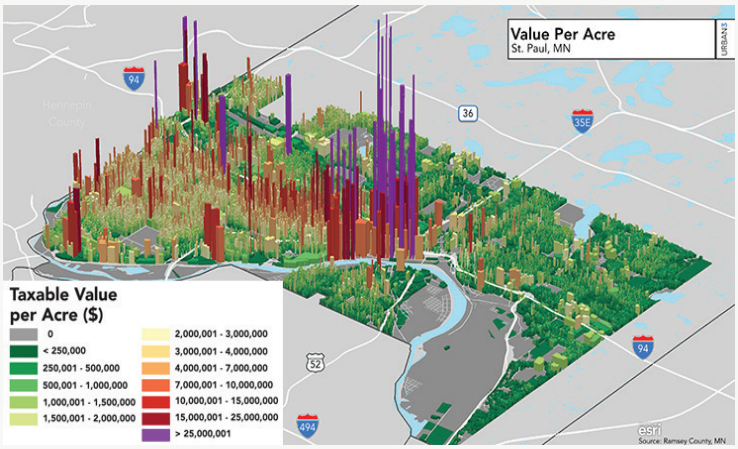
An outcome of expended streets and highways and subsequent suburbanization of metro areas is that all of the other infrastructure systems to support new residential developments must be expanded, including water, sewer, telecommunications, and power. A variety of state and local policies encourage and subsidize this style of suburban sprawl land use that has led to infrastructure systems that are larger than our ability to maintain them in good repair. The established land-use patterns and associated infrastructure costs in Michigan are the result of over 70 years of automobile-focused development.

One method to evaluate the fiscal sustainability of the built environment is to conduct a "value per acre" analysis. Such an approach can help to understand if activity taking place within an area creates enough wealth to support the required infrastructure and services. This can be done using geographical analysis of public tax records. While such an analysis is not known to have been performed in Michigan, there are many examples, such as is visualized in **Figure 13**, below, for St. Paul Minnesota.

Such a value per acre analysis can be extended to better understand what land uses are contributing wealth to an area by merging per acre value data with an estimated cost of infrastructure and services.[155] Such an analysis is shown in **Figure 14**, below, for Lafayette, Louisiana.

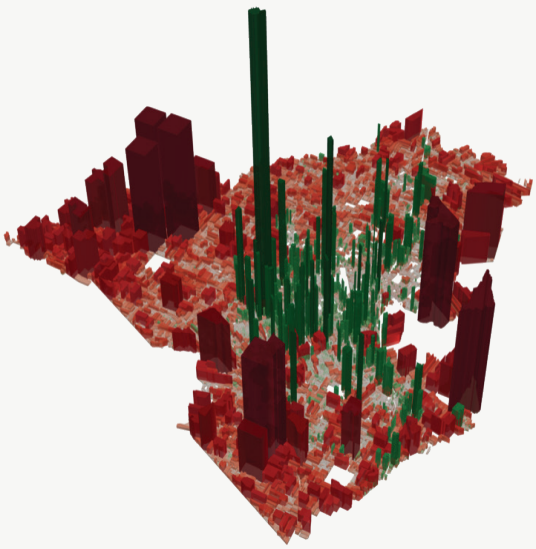
[155] Urban Prosperity Network. How to Calculate and Visualize Value per Acre in Your City.

Figure 13: Value per Acre Analysis of St. Paul, Minnesota.



Source: Urban3 via MinnPost

Figure 14: Estimated cash flow by parcel for Lafayette, LA (Green is cash flow positive. Red is cash flow negative.)



Source: Urban3 via MinnPost

These analyses typically provide results that may be counterintuitive to many policymakers. The most economically productive downtown parcels tend to be residential buildings more than 90 years old.[156] These areas are often perceived as blighted. However, due to the dense land use of pre 1950 neighborhoods, these disinvested neighborhoods remain economic cornerstones of a city and region.

Such an evaluation has never been conducted for any Michigan cities. However, it has been understood for some time that sprawl-style development impairs the Michigan's fiscal outlook.

In 2003, the Michigan Land Use Leadership Council found that, "Government policies … have directly or indirectly encouraged sprawl. In Michigan, sprawling growth has had a negative effect on large urban core areas, older suburban areas, and the downtown areas of many medium sized and small towns. It has resulted in disinvestment in central cities, a decrease in tax base, and an increase in the costs of basic services."[157]

[156] Bill Lindeke. Per-acre Analysis: a unique way of looking at urban economics. MinnPost. February 16, 2021.
[157] Michigan Land Use Leadership Council. "Michigan's Land, Michigan's Future." August 15, 2003.

Transportation planning and other state policies have encouraged and continue to encourage suburban sprawl. The increasing amount of infrastructure per user has required us to continually raise taxes and utility rates, yet funding gaps continue to increase and Michigan's infrastructure is still perceived to be in a crisis. It will take decades of effort and a lot of luck to reestablish a built environment that is fiscally sustainable. This effort must begin by identifying the policies that have contributed to this problem.

- Transportation planning in Michigan must incorporate the well-established idea of induced demand.[158] By expanding highways, roads, and streets, Michigan encourages not only more traffic, but a redistribution of residential and commercial land uses to the outer periphery of urban areas. This requires the build-out of expensive supporting infrastructure (water, power, telecommunications). Expansion of infrastructure in an era of flat population growth amplifies funding challenges. Public policies should seek to minimize further road and highway expansion projects until this relationship and our fiscal situation is better understood.
- Michigan's water infrastructure should be managed more coherently and wholistically. All water is connected. Poor stormwater management and environmental policies create pollution that impacts watersheds, which increases the cost of drinking water treatment. Public policies should encourage the adoption of stormwater utilities to fund and manage stormwater infrastructure, which link costs of stormwater management to the impacts by land use.
- Public policies should balance efforts to decarbonize Michigan's infrastructure with challenges related to providing reliable and affordable electric power.
- Public policies that subsidize the build-out of broadband infrastructure should adopt meaningful cost-benefit criteria. Issues of affordability and equity should also be emphasized. Restrictions on municipal broadband should be lifted.
- Michigan's approach to infrastructure asset management should emphasize objective performance-based metrics with established relationships to infrastructure costs and service quality.
- Michigan should pursue public policies that coordinate infrastructure investment, planning, and project delivery to emphasize shared goals and broad social benefits.

[158] Adam Mann. "What's Up With That: Building Bigger Roads Actually Makes Traffic Worse." Wired. June 17, 2014.