



THE UNIVERSITY OF CHICAGO
THE LAW SCHOOL
Abrams Environmental
Law Clinic

June 24, 2024

Via E-Filing

Ms. Lisa Felice
Executive Secretary
Michigan Public Service Commission
7109 West Saginaw Highway
Lansing, MI 48917

RE: MPSC Case No. U-21291

Dear Ms. Felice:

Please find enclosed the Updated Exhibit List and Official Exhibits FLO-1 to FLO-6 sponsored by Jackson Koepfel (Part 1 of 13) on Behalf of Frontline Organizations, along with proof of service for electronic filing in the above-referenced matter. Please do not hesitate to contact me with any questions or comments.

Sincerely,

A handwritten signature in black ink, appearing to read "Mark N. Templeton".

Mark N. Templeton, *pro hac vice*
6020 S. University Avenue
Chicago, IL 60637
Phone: (773) 702-9611
Email: templeton@uchicago.edu

xc: Parties to Case No. U-21291

STATE OF MICHIGAN

BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

In the matter of the Application of **DTE GAS
COMPANY** for authority to increase its rates,
amend its rate schedules and rules governing the
distribution and supply of natural gas, and for
miscellaneous accounting authority.

U-21291

ALJ Jonathan F. Thoits

UPDATED EXHIBIT LIST

ON BEHALF OF

SOULARDARITY, URBAN CORE COLLECTIVE, AND WE WANT GREEN, TOO

(COLLECTIVELY, FRONTLINE ORGANIZATIONS (FLO))

June 18, 2024

Sponsoring Witness: Jackson Koeppel

- FLO-1. DTE Energy Co., Annual Report (Form 10-K) (Feb. 8, 2024) (excerpt).
- FLO-2. Karlee Weinmann, *Amid Controversies, DTE Energy Continues to Spend Big in Michigan and Nearly Every Lawmaker Accepts*, ENERGY & POL’Y INST. (Sept. 28, 2022), <https://energyandpolicy.org/dte-energy-political-contributions-michigan/>.
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- FLO-5. LAURA FRIER, DELIA MAYOR & BRETT ZEUNER, ASSESSING THE STATE OF ENVIRONMENTAL JUSTICE IN MICHIGAN (May 2019) (available at https://deepblue.lib.umich.edu/bitstream/handle/2027.42/149105/AssessingtheStateofEnvironmentalJusticeinMichigan_344.pdf?sequence=1&isAllowed=y).
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- FLO-7. Karin Kirk, *Which State Is Winning at Renewable Energy Production?*, YALE CLIMATE CONNECTIONS (Feb. 23, 2022),

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- FLO-9. VIBRANT CLEAN ENERGY, LLC, ELECTRIFICATION AND DECARBONIZATION PATHWAYS FOR MICHIGAN (2022).
- FLO-10. Andy Balaskovitz, *Utility-linked group seeks to dismantle net metering in Michigan*, ENERGY NEWS NETWORK (Mar. 4, 2019), <https://energynews.us/2019/03/04/utility-linked-group-seeks-to-dismantle-net-metering-in-michigan/>.
- FLO-11. Erik Pohl et al., *Distribution Grid Impact Study in Highland Park, Michigan: Understanding Rooftop Solar, Behind-the-Meter Energy Storage, Electric Vehicle Charging, and Building Electrification*, U.S. DEP'T OF ENERGY, (2024) (available at <https://www.nrel.gov/docs/fy24osti/87916.pdf>).
- FLO-12. Weiwei Lin et al., *Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children*, 42 INT. J. EPIDEMIOLOGY 1724 (2023).
- FLO-13. PRUDENCE KUNYANGNA & BETH ANDERSON, DETROIT: THE CURRENT STATUS OF ASTHMA BURDEN (2021).
- FLO-14. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.12.
- FLO-15. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.13–FLODG-3.15.
- FLO-16. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.17.

- FLO-17. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.19.
- FLO-18. Courtney Lindwall, *Decarbonization: Why We Must Electrify Everything Even Before the Grid Is Fully Green*, NAT. RES. DEF. COUNCIL (Dec. 1, 2022), <https://www.nrdc.org/stories/why-we-must-electrify-everything-even-grid-fully-green>.
- FLO-19. ARJUN MAKHIJANI, THE TROUBLE WITH STRIDE: MEETING CLIMATE GOALS AND ADDRESSING NATURAL GAS SYSTEM STRANDED COSTS (Dec. 2023) (available at <https://ieer.org/wp/wp-content/uploads/2024/01/Natural-gas-stranded-costs-and-climate-A-Maryland-case-study-2023-12.pdf>).
- FLO-20. Isaac Sevier, *Building Decarbonization has a Natural Gas Pipeline Problem*, CLIMATE + CMTY. PROJECT (May 17, 2023), <https://www.climateandcommunity.org/building-decarb-natural-gas-problem>.
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- FLO-22. DTE Gas's Response to CEO's First Discovery Request, CEODG-1.15a.
- FLO-23. DTE Gas's Response to MNSC's Fifth Discovery Request, MNSCDG-5.10b.
- FLO-24. DTE GAS COMPANY, LOW CARBON ENERGY INFRASTRUCTURE ENHANCEMENT AND DEVELOPMENT GRANT PROPOSAL: EXPANSION OF NATURAL GAS DISTRIBUTION SYSTEMS IN BENZIE, MANISTEE, AND WEXFORD COUNTIES (2023).
- FLO-25. DTE GAS COMPANY, LOW CARBON ENERGY INFRASTRUCTURE ENHANCEMENT AND DEVELOPMENT GRANT PROPOSAL: EXPANSION OF NATURAL GAS DISTRIBUTION SYSTEMS IN NEWAGO COUNTY (2023).

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- FLO-30. DTE Gas's Response to FLO's Fifth Discovery Request, FLODG-5.1b, 5.1c(i)-(iii), 5.2b, 5.2c(i)-(iii), 5.3b, 5.3c(i)-(iii).
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- FLO-35. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.10a.
- FLO-36. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.10b.
- FLO-37. Brian Allnutt, *U.S. Senators Accuse DTE-Chaired American Gas Association of Using Customer Money to Mislead Public*, PLANET DETROIT (May 1,

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- FLO-44. AMERICAN COUNCIL FOR AN ENERGY EFFICIENT ECONOMY, UNDERSTANDING ENERGY AFFORDABILITY (Sep. 9, 2019).
- FLO-45. DTE Gas’s Response to FLO’s Sixth Discovery Request, FLODG-6.11, 6.12, 6.13.

- FLO-46. ELECTRICITY CONSUMERS RESOURCE COUNCIL, REVENUE DECOUPLING AND ITS ALTERNATIVES: AN INTERVENER’S GUIDE TO RETAIL RATEMAKING AND POLICIES ON DECOUPLING (2009).
- FLO-47. *MPSC Approves \$50M in Low-Carbon Energy Infrastructure Grants*, MICH. PUB. SERV. COMM’N (June 9, 2023), [https://www.michigan.gov/mpsc/commission/news-releases/2023/06/09/mpsc-approves-\\$50m-in-low-carbon-energy-infrastructure-grants](https://www.michigan.gov/mpsc/commission/news-releases/2023/06/09/mpsc-approves-$50m-in-low-carbon-energy-infrastructure-grants).

Sponsoring Witness: Justin Schott

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- FLO-102. SHALANDA BAKER, SUBIN DEVAR & SHIVA PRAKASH, INITIATIVE FOR ENERGY JUST., THE ENERGY JUSTICE WORKBOOK (2019).
- FLO-103. Diana Hernández, *Understanding “Energy Insecurity” and Why It Matters to Health*, SOC. SCI. & MED., no. 167, 2016.
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- FLO-108. *Low-Income Self-Sufficiency Plan*, DTE (last accessed Apr. 30, 2024), <https://www.dteenergy.com/us/en/residential/billing-and-payments/energy-assistance/low-income-self-sufficiency-plan.html>.
- FLO-109. Justin Schott, JS FLO Working Paper 1.
- FLO-110. DTE Gas's Response to FLO's First Discovery Request, FLODG-1.18a.
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- FLO-119. Janjala Chirakija, Seema Jayachandran & Pinchuan Ong, *Inexpensive Heating Reduces Winter Mortality* (Nat'l Bureau of Econ. Rsch., Working Paper No. 25681, 2019).
- FLO-120. Michelle Graff, David M. Konisky, Sanya Carley & Trevor Memmott, *Climate Change and Energy Insecurity: A Growing Need for Policy Intervention*, 15 ENV'T JUST, no. 2, 2022.
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- FLO-127. ARIEL DREHOBL & LAUREN ROSS, AM. COUNCIL FOR AN ENERGY-EFFICIENT ECON., LIFTING THE HIGH ENERGY BURDEN IN AMERICA’S LARGEST CITIES: HOW ENERGY EFFICIENCY CAN IMPROVE LOW INCOME AND UNDERSERVED COMMUNITIES (2016).
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- FLO-138. Justin Schott, FLO JS Workpaper 5.
- FLO-139. REVISED QUARTERLY REPORT FOR 1ST, 2ND, AND 3RD QUARTERS OF 2023, DTE (2023).
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- FLO-149. DTE Gas's Response to FLO's First Discovery Request, FLODG-1.9.
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- FLO-153. MICH. DEP'T OF HEALTH & HUM. SERVS., DETROIT: THE CURRENT STATUS OF ASTHMA BURDEN (2021).
- FLO-154. Excerpt from Ill. Com. Comm'n No. 23-0067, Order (Nov. 16, 2023).
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Sponsoring Witness: Sergio Cira-Reyes

- FLO-201. *About the Collective*, URB. CORE COLLECTIVE (last updated Apr. 6, 2018), <https://www.urbancorecollective.org/about>.
- FLO-202. C4, ZERO CITIES PROJECT & HEZERO: MPSC EWR – LI MEETING (2021).
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- FLO-222. DTE Gas’s Response to FLO’s Second Discovery Request, FLODG-2.3b–2.4b.
- FLO-223. DTE Gas’s Response to FLO’s First Discovery Request, FLODG-1.18c.
- FLO-224. DTE Gas’s Response to FLO’s First Discovery Request, FLODG-1.18a.
- FLO-225. DTE Gas’s Response to FLO’s First Discovery Request, FLODG-1.17.
- FLO-226. DTE Gas’s Response to FLO’s Second Discovery Request, FLODG-2.1.
- FLO-227. DTE Gas’s Response to FLO’s Third Discovery Request, U-21291 FLODG-3.5d 03 Payment Assist Bill Insert 2023-24.

- FLO-228. *Low-Income Programs*, DTE (last accessed May 4, 2024), <https://perma.cc/AX5K-FGYX>.
- FLO-229. DTE Gas's Response to FLO's Third Discovery Request, FLODG-3.4b–3.4c.
- FLO-230. DTE Gas's Response to FLO's Third Discovery Request, U-21291 FLODG-3.6a Gas_LIA-LSP and non-LSP.
- FLO-231. DTE Gas's Response to FLO's Third Discovery Response, FLODG-3.1a–3.1b.
- FLO-232. DTE Gas's Response to FLO's Third Discovery Response, FLODG-3.2.
- FLO-233. DTE Gas's Response to FLO's Second Discovery Request, FLODG-2.6a.
- FLO-234. DTE Gas's Response to FLO's First Discovery Request, FLODG-1.19.
- FLO-235. DTE Gas's Response to FLO's First Discovery Request, FLODG-3.3a–3.3b.
- FLO-236. DTE Gas's Response to FLO's Seventh Discovery Request, FLODG-7.1b.
- FLO-237. *What Is Average Speed of Answer? Strategies and Calculation*, CALL CTR. STUDIO (Jan. 5, 2024), <https://callcenterstudio.com/blog/what-is-average-speed-of-answer-strategies-and-calculation/>.
- FLO-238. *Michigan Energy Assistance Program Frequently Asked Questions*, MICH. PUB. SERV. COMM'N (last accessed May 4, 2024), https://www.michigan.gov/-/media/Project/Websites/mpsc/consumer/meap/MEAP_FAQs.pdf?rev=2ba17357b585490195c365457037102c.
- FLO-239. **CONFIDENTIAL** – DTE Gas's Response to FLO's Third Discovery Request, NDA U-21291 FLODG 7.1f Customer Call Handling JA-CS-COLL-035 v.2.

FLO-240. DTE Gas's Response to FLO's Third Discovery Request, U-21291 FLODG-3.5a-c 2021-2024 CAD CRF POP UPS.

FLO-241. *BudgetWise Billing*, DTE (last accessed Apr. 19, 2024), <https://www.dteenergy.com/us/en/business/billing-and-payments/payment-programs/bwb.html>.

FLO-242. DTE Gas's Response to FLO's Fourth Discovery Request, FLODG-4.1d.

Sponsoring Witness: Toyia Watts

FLO-301. DTE Gas's Response to FLO's Third Discovery Request, U-21291 FLODG-3.5d 03 Payment Assist Bill Insert 2023-24.

FLO-302. *Customer Resource Fairs*, DTE (last accessed 5/2/2024), <https://perma.cc/NLS3-BMTY>.

FLO-303. DTE Gas's Response to FLO's Third Discovery Request, U-21291 FLODG3.5-a-c 2024-2024 CAD CRF POP UPS.

FLO-304. DTE Gas's Response to FLO's Second Discovery Request, FLODG-2.3b.

FLO-305. DTE Gas's Response to FLO's Second Discovery Request, FLODG-2.4a.

Admission Agreed with DTE in Lieu of Cross

FLO-401. U-21291 FLODG 5.1a 2022 Clarington RSG CONFIRMATION.

FLO-402. U-21291 FLODG 5.2a 2022 Falcon RSG CONFIRMATION.

FLO-403. U-21291 FLODG 5.3a 2022 PEPL RSG CONFIRMATION.

FLO-404. OIL CHANGE INT'L, CERTIFIED DISASTER: HOW PROJECT CANARY & GAS CERTIFICATION ARE MISLEADING MARKETS & GOVERNMENTS (2023).

- FLO-405. GLOB. WITNESS, US GAS CAN'T CERTIFY AWAY ITS CLIMATE AND ENVIRONMENTAL JUSTICE PROBLEMS: A CASE STUDY ON MIQ AND EXXON (2022).
- FLO-406. DTE Gas's Response to AG's Eighth Discovery Request, AGDG-8.237a-b.
- FLO-407. DTE Gas's Response to AG's Eighth Discovery Request, AGDG-8.239.
- FLO-408. DTE Gas's Response to FLO's Eighth Discovery Request, FLODG-8.2a.
- FLO-409. DTE Gas's Response to FLO's Eighth Discovery Request, FLODG-8.3d & U-21291 FLODG- 8.3d Invoices.
- FLO-410. *American Gas Association*, ENERGY & POL'Y INST. (last accessed June 15, 2024), <https://energyandpolicy.org/american-gas-association/>.
- FLO-411. DTE Gas's Response to FLO's Eighth Discovery Request, FLODG-8.4–8.6 & U-21291 FLODG-8.5 RM&P Actuals and Projections.
- FLO-412. DTE Gas's Response to FLO's Eighth Discovery Request, FLODG-8.7b–8.9b.
- FLO-413. **CONFIDENTIAL** – DTE Gas's Response to FLO's Eighth Discovery Request, NDA U-21291 FLODG-8.8d Bill Analysis after LSP.
- FLO-414. DTE Gas's Response to FLO's Eighth Discovery Request, FLODG-8.10.

UNITED STATES SECURITIES AND EXCHANGE COMMISSION

Washington, D.C. 20549

FORM 10-K

☒ ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934

For the Fiscal Year Ended December 31, 2023

Or

☐ TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934

For the transition period from ____ to ____



Commission File Number: 1-11607

DTE Energy Company

Michigan

(State or other jurisdiction of incorporation or organization)

38-3217752

(I.R.S Employer Identification No.)

Commission File Number: 1-2198

DTE Electric Company

Michigan

(State or other jurisdiction of incorporation or organization)

38-0478650

(I.R.S Employer Identification No.)

Registrants address of principal executive offices: One Energy Plaza, Detroit, Michigan 48226-1279

Registrants telephone number, including area code: (313) 235-4000

Securities registered pursuant to Section 12(b) of the Act:

Registrant	Title of Each Class	Trading Symbol(s)	Name of Exchange on which Registered
DTE Energy Company (DTE Energy)	Common stock, without par value	DTE	New York Stock Exchange
DTE Energy	2017 Series E 5.25% Junior Subordinated Debentures due 2077	DTW	New York Stock Exchange
DTE Energy	2020 Series G 4.375% Junior Subordinated Debentures due 2080	DTB	New York Stock Exchange
DTE Energy	2021 Series E 4.375% Junior Subordinated Debentures due 2081	DTG	New York Stock Exchange
DTE Electric Company (DTE Electric)	None		None

Securities registered pursuant to Section 12(g) of the Act:

DTE Energy	None	DTE Electric	None
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Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act.

DTE Energy	Yes	☒ No	☐	DTE Electric	Yes	☒ No	☐
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Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act.

DTE Energy	Yes	☐ No	☒	DTE Electric	Yes	☐ No	☒
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Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days.

DTE Energy	Yes	☒ No	☐	DTE Electric	Yes	☒ No	☐
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Indicate by check mark whether the registrant has submitted electronically every Interactive Data File required to be submitted pursuant to Rule 405 of Regulation S-T during the preceding 12 months (or for such shorter period that the registrant was required to submit such files).

DTE Energy Yes ☒ No ☐ **DTE Electric** Yes ☒ No ☐

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company, or an emerging growth company. See the definitions of "large accelerated filer," "accelerated filer," "smaller reporting company," and "emerging growth company" in Rule 12b-2 of the Exchange Act.

DTE Energy	Large accelerated filer	Accelerated filer	Non-accelerated filer	Smaller reporting company	Emerging growth company
	☒	☐	☐	☐	☐
DTE Electric	Large accelerated filer	Accelerated filer	Non-accelerated filer	Smaller reporting company	Emerging growth company
	☐	☐	☒	☐	☐

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Indicate by check mark whether the registrant has filed a report on and attestation to its management's assessment of the effectiveness of its internal control over financial reporting under Section 404(b) of the Sarbanes-Oxley Act (15 U.S.C. 7262(b)) by the registered public accounting firm that prepared or issued its audit report.

DTE Energy Yes ☒ No ☐ **DTE Electric** Yes ☐ No ☒

If securities are registered pursuant to Section 12(b) of the Act, indicate by check mark whether the financial statements of the registrant included in the filing reflects the correction of an error to previously issued financial statements.

DTE Energy ☐ **DTE Electric** ☐

Indicate by check mark whether any of those error corrections are restatements that required a recovery analysis of incentive based compensation received by any of the registrants' executive officers during the relevant recovery period pursuant to §240.10D-1(b).

DTE Energy ☐ **DTE Electric** ☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Act).

DTE Energy Yes ☐ No ☒ **DTE Electric** Yes ☐ No ☒

On June 30, 2023, the aggregate market value of DTE Energy's voting and non voting common equity held by non-affiliates was approximately \$22.6 billion (based on the New York Stock Exchange closing price on such date).

Number of shares of Common Stock outstanding at January 31, 2024:

Registrant	Description	Shares
DTE Energy	Common Stock, without par value	206,452,985
DTE Electric	Common Stock, \$10 par value, indirectly-owned by DTE Energy	138,632,324

DOCUMENTS INCORPORATED BY REFERENCE

Certain information in DTE Energy's definitive Proxy Statement for its 2024 Annual Meeting of Common Shareholders to be held May 2, 2024, which will be filed with the Securities and Exchange Commission pursuant to Regulation 14A, not later than 120 days after the end of the Registrants' fiscal year covered by this report on Form 10-K, is incorporated herein by reference to Part III (Items 10, 11, 12, 13, and 14) of this Form 10-K.

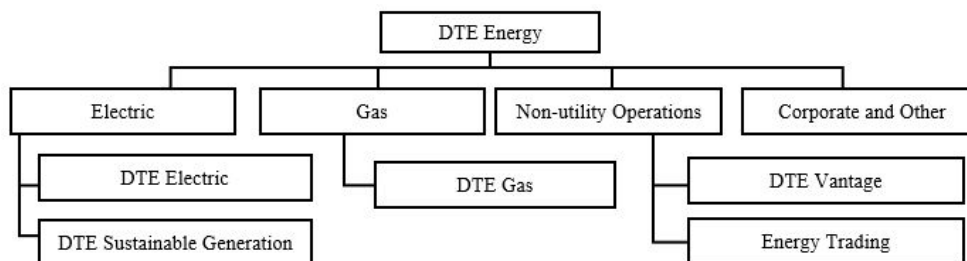
This combined Form 10-K is filed separately by two registrants: DTE Energy and DTE Electric. Information contained herein relating to any individual registrant is filed by such registrant solely on its own behalf. DTE Electric makes no representation as to information relating exclusively to DTE Energy.

DTE Electric, an indirect wholly-owned subsidiary of DTE Energy, meets the conditions set forth in General Instructions I(1)(a) and (b) of Form 10-K and is therefore filing this form with the reduced disclosure format specified in General Instruction I(2) of Form 10-K.

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Corporate and Other

- Corporate and Other includes various holding company activities, holds certain non-utility debt, and holds certain investments, including funds supporting regional development and economic growth.



Refer to Management's Discussion and Analysis in Item 7 of this Report for an in-depth analysis of each segment's financial results. A description of each business unit follows.

ELECTRIC

Description

DTE Energy's Electric segment consists principally of DTE Electric, an electric utility engaged in the generation, purchase, distribution, and sale of electricity to approximately 2.3 million customers in southeastern Michigan. DTE Electric is regulated by numerous federal and state governmental agencies, including, but not limited to, the MPSC, the FERC, the NRC, the EPA, and EGLE. Electricity is primarily generated by two coal-fired plants, a combined cycle natural gas plant, a hydroelectric pumped storage plant, a nuclear plant, wind and solar assets, and is supplemented with purchased power. The electricity is sold, or distributed through the retail access program, to three major classes of customers: residential, commercial, and industrial, throughout southeastern Michigan.

Weather, economic factors, competition, energy waste reduction initiatives, and electricity prices affect sales levels to customers. DTE Electric's peak load and highest total system sales generally occur during the third quarter of the year, driven by air conditioning and other cooling-related demands. DTE Electric's operations are not dependent upon a limited number of customers, and the loss of any one or a few customers would not have a material adverse effect on the results of DTE Electric.

The Electric segment also includes non-utility operations relating to renewable energy projects at DTE Sustainable Generation, which were acquired to support DTE Energy's renewable energy goals.

For a summary of Electric segment operating revenues by service, see Note 5 to the Consolidated Financial Statements, "Revenue."

Fuel Supply and Purchased Power

DTE Electric's power is generated primarily from a variety of fuels and is supplemented with renewable generation and purchased power. DTE Electric expects to have an adequate supply of power to meet its obligation to serve customers. DTE Electric's generating capability is largely dependent upon the availability of coal and natural gas.

Coal is purchased from various sources in different geographic areas under agreements that vary in both pricing and terms. DTE Electric expects to obtain the majority of its coal requirements through long-term contracts, with the balance to be obtained through short-term agreements and spot purchases. DTE Electric has long-term and short-term contracts for the purchase of approximately 8.6 million tons of low-sulfur western coal and approximately 1.0 million tons of Appalachian coal to be delivered from 2024 to 2025. All of these contracts have pricing schedules. DTE Electric has 97% of its expected coal requirements under contract for 2024. DTE Electric leases a fleet of rail cars and has the expected western and eastern coal rail requirements under multi-year contracts. DTE Electric's 2024 rail transportation is covered under long-term agreements. DTE Electric expects to cover all of its 2024 vessel transportation requirements for delivery of purchased coal to electric generating facilities through existing agreements.

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DTE Electric's natural gas supply requirements are expected to be met through a combination of short and long-term agreements, agreements with local distribution companies, and spot market purchases. Natural gas purchase requirements for 2024 are expected to be approximately 63 Bcf. DTE Electric has contracts for firm gas transportation and storage capacity to ensure reliable and flexible gas supply to its power plants. Given the geographic diversity of supply, DTE Electric believes it can meet its expected generation requirements.

DTE Electric participates in the energy market through MISO. DTE Electric offers its generation in the market on a day-ahead and real-time basis and bids for power in the market to serve its load. DTE Electric is a net purchaser of power that supplements its generation capability to meet customer demand during peak cycles or during major plant outages.

Properties

DTE Electric owns generating facilities that are located in the State of Michigan. Substantially all of DTE Electric's property is subject to the lien of a mortgage.

Generating facilities owned and in service as of December 31, 2023 for the electric segment are shown in the following table:

Facility	Location by Michigan County	Year in Service	Net Generation Capacity ^(a) (MW)
Fossil-fueled Steam-Electric			
Coal			
Monroe ^(b)	Monroe	1971, 1973, and 1974	3,066
Belle River ^(c)	St. Clair	1984 and 1985	1,034
Natural Gas/Oil			
Greenwood	St. Clair	1979	785
Natural Gas/Combined Cycle			
Blue Water Energy Center	St. Clair	2022	1,143
Dearborn	Wayne	2019	35
			6,063
Natural gas and Oil-fueled Peaking Units	Various	1966-1971, 1981, 1999, 2002, and 2003	1,969
Nuclear-fueled Steam-Electric Fermi 2	Monroe	1988	1,141
Hydroelectric Pumped Storage Ludington^(d)	Mason	1973	1,122
Renewables^(e)			
Wind Utility	Various	2011-2023	1,491
Wind Non-Utility	Various	2019 and 2020	106
Solar Utility	Various	2010-2021	65
Solar Non-Utility	Delta	2019 and 2022	2
			1,664
			11,959

(a) Represents summer net rating for all units with the exception of renewable facilities. The summer net rating is based on operating experience, the physical condition of units, environmental control limitations, and customer requirements for steam, which would otherwise be used for electric generation. Wind and solar facilities reflect name plate capacity measured in alternating current.

(b) The Monroe generating plant provided 32% of DTE Electric's total 2023 power plant generation.

(c) Represents DTE Electric's 81% interest in Belle River with a total capability of 1,270 MW. See Note 7 to the Consolidated Financial Statements, "Jointly-Owned Utility Plant."

(d) Represents DTE Electric's 49% interest in Ludington with a total capability of 2,290 MW. See Note 7 to the Consolidated Financial Statements, "Jointly-Owned Utility Plant."

(e) In addition to the owned renewable facilities described above, DTE Electric has long-term contracts for 560 MW of renewable power generated from wind, solar, and biomass facilities. Of that amount, currently 52 MW relates to power purchase agreements with DTE Sustainable Generation.

See "Capital Investments" in Management's Discussion and Analysis in Item 7 of this Report for information regarding plant retirements and future capital expenditures.

DTE Electric owns and operates 701 distribution substations with a capacity of approximately 37,650,000 kilovolt-amperes (kVA) and approximately 453,700 line transformers with a capacity of approximately 33,359,000 kVA.

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Circuit miles of electric distribution lines owned and in service as of December 31, 2023 are shown in the following table:

Operating Voltage-Kilovolts (kV)	Circuit Miles	
	Overhead	Underground
4.8 kV to 13.2 kV	28,556	13,454
24 kV	170	701
40 kV	2,338	445
120 kV	58	8
	31,122	14,608

There are numerous interconnections that allow the interchange of electricity between DTE Electric and electricity providers external to the DTE Electric service area. These interconnections are generally owned and operated by ITC Transmission, an unrelated company, and connect to neighboring energy companies.

Regulation

DTE Electric is subject to the regulatory jurisdiction of various agencies, including, but not limited to, the MPSC, the FERC, and the NRC. The MPSC issues orders pertaining to rates, recovery of certain costs, including the costs of generating facilities and regulatory assets, conditions of service, accounting, and operating-related matters. DTE Electric's MPSC-approved rates charged to customers have historically been designed to allow for the recovery of costs, plus an authorized rate of return on investments. The FERC regulates DTE Electric with respect to financing authorization, wholesale electric market activities, certain affiliate transactions, the acquisition and disposition of certain generation and other facilities, and, in conjunction with the NERC, compliance with mandatory reliability standards. The NRC has regulatory jurisdiction over all phases of the operation, construction, licensing, and decommissioning of DTE Electric's nuclear plant operations. DTE Electric is subject to the requirements of other regulatory agencies with respect to safety, the environment, and health.

See Notes 8, 9, 12, 18, and 19 to the Consolidated Financial Statements, "Asset Retirement Obligations," "Regulatory Matters," "Fair Value," "Commitments and Contingencies," and "Nuclear Operations."

Energy Assistance Programs

Energy assistance programs, funded by the federal government and the State of Michigan, remain critical to DTE Electric's ability to control its uncollectible accounts receivable and collections expenses. DTE Electric's uncollectible accounts receivable expense is directly affected by the level of government-funded assistance that qualifying customers receive. DTE Electric works continuously with the State of Michigan and others to determine whether the share of funding allocated to customers is representative of the number of low-income individuals in the service territory. DTE Electric also partners with federal, state, and local officials to attempt to increase the share of low-income funding allocated to customers.

Strategy and Competition

DTE Electric's electrical generation operations seek to provide the energy needs of customers in a cost-effective manner and support DTE Energy's goal to reduce carbon emissions by 65% in 2028, 85% in 2032, and 90% by 2040 from 2005 carbon emissions levels, as well as net zero emissions by 2050. With potential capacity constraints in the MISO region, there will be increased dependency on DTE Electric's generation to provide reliable service and price stability for customers.

Additionally, as a result of legislation passed by the state of Michigan in the fourth quarter 2023, DTE Electric will be required to meet a 100% clean energy portfolio standard by 2040. Clean energy sources include renewables, nuclear, and natural gas-fired plants, provided such plants utilize a carbon capture and storage system that is at least 90% effective to offset carbon emissions. The legislation also requires 50% of an electric utility's energy to be generated from renewable sources by 2030 and 60% by 2035. DTE Electric is currently assessing the impacts of this legislation and will include updates in its next Integrated Resource Plan to comply with the new requirements.

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Item 3. *Legal Proceedings*

For more information on legal proceedings and matters related to the Registrants, see Notes 9 and 18 to the Consolidated Financial Statements, "Regulatory Matters" and "Commitments and Contingencies," respectively.

For environmental proceedings in which the government is a party, the Registrants include disclosures if any sanctions of \$1 million or greater are expected.

Item 4. *Mine Safety Disclosures*

Not applicable.

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Part II

Item 5. Market for Registrant's Common Equity, Related Stockholder Matters, and Issuer Purchases of Equity Securities

DTE Energy common stock is listed under the ticker symbol "DTE" on the New York Stock Exchange, which is the principal market for such stock.

At December 31, 2023, there were 206,357,070 shares of DTE Energy common stock outstanding. These shares were held by a total of 41,918 shareholders of record.

All of the 138,632,324 issued and outstanding shares of DTE Electric common stock, par value \$10 per share, are indirectly-owned by DTE Energy, and constitute 100% of the voting securities of DTE Electric. Therefore, no market exists for DTE Electric's common stock.

For information on DTE Energy dividend restrictions, see Note 16 to the Consolidated Financial Statements, "Short-Term Credit Arrangements and Borrowings."

All of DTE Energy's equity compensation plans that provide for the annual awarding of stock-based compensation have been approved by shareholders. For additional detail, see Note 21 to the Consolidated Financial Statements, "Stock-Based Compensation."

See the following table for information as of December 31, 2023:

	Number of Securities to be Issued Upon Exercise of Outstanding Options	Weighted-Average Exercise Price of Outstanding Options	Number of Securities Remaining Available for Future Issuance Under Equity Compensation Plans
Plans approved by shareholders	—	\$ —	2,820,677

UNREGISTERED SALES OF DTE ENERGY EQUITY SECURITIES AND USE OF PROCEEDS

Purchases of DTE Energy Equity Securities by the Issuer and Affiliated Purchasers

The following table provides information about DTE Energy's purchases of equity securities that are registered by DTE Energy pursuant to Section 12 of the Exchange Act of 1934 for the quarter ended December 31, 2023:

	Number of Shares Purchased ^(a)	Average Price Paid per Share ^(a)	Number of Shares Purchased as Part of Publicly Announced Plans or Programs	Average Price Paid per Share	Maximum Dollar Value that May Yet Be Purchased Under the Plans or Programs
10/01/2023 — 10/31/2023	1,125	\$ 101.71	—	—	—
11/01/2023 — 11/30/2023	851	\$ 109.23	—	—	—
12/01/2023 — 12/31/2023	759	\$ 113.15	—	—	—
Total	<u>2,735</u>		<u>—</u>		

(a) Primarily represents shares of DTE Energy common stock withheld to satisfy income tax obligations upon the vesting of restricted stock based on the market price at the vesting date.

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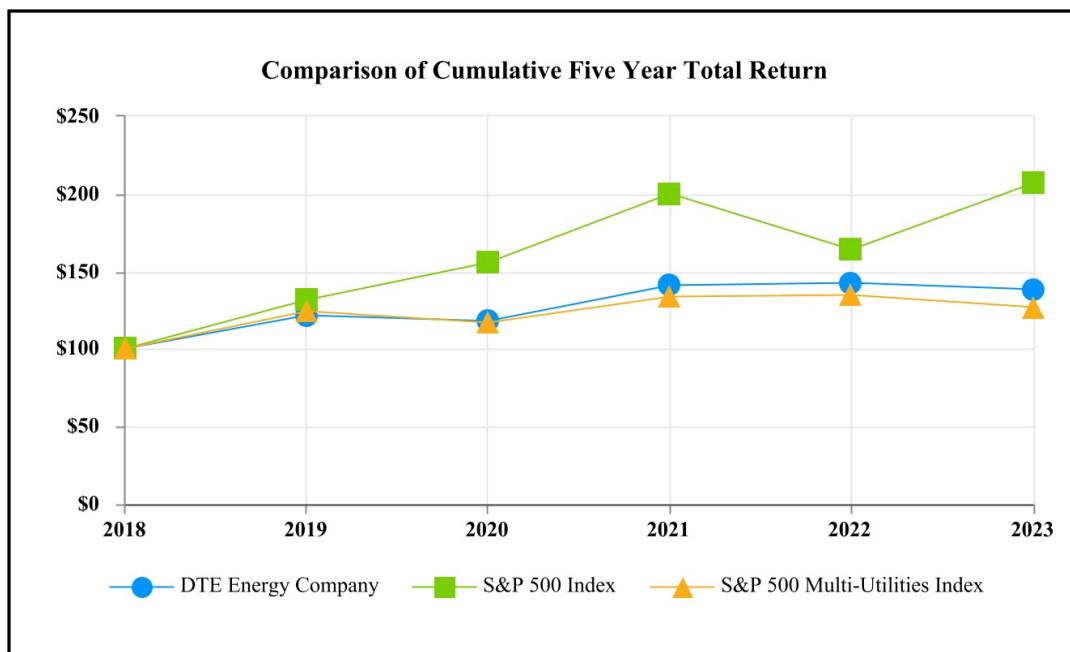
COMPARISON OF CUMULATIVE FIVE YEAR TOTAL RETURN

Total Return to DTE Energy Shareholders

(Includes reinvestment of dividends)

Company/Index	Annual Return Percentage Year Ended December 31,					
	2019	2020	2021	2022	2023	
DTE Energy Company	21.36	(2.90)	19.42	1.27	(2.81)	
S&P 500 Index	31.48	18.39	28.68	(18.13)	26.26	
S&P 500 Multi-Utilities Index	24.36	(5.87)	14.17	0.62	(5.82)	

Company/Index	Indexed Returns Year Ended December 31,					
	Base Period 2018	2019	2020	2021	2022	2023
DTE Energy Company	100.00	121.36	117.84	140.72	142.50	138.49
S&P 500 Index	100.00	131.48	155.65	200.29	163.98	207.04
S&P 500 Multi-Utilities Index	100.00	124.36	117.06	133.64	134.46	126.63



Item 6. [Reserved]

energyandpolicy.org

Amid controversies, DTE Energy continues to spend big in Michigan and nearly every lawmaker accepts

Karlee Weinmann

17–21 minutes

Key Points:

- Nearly every member of the Michigan legislature has accepted DTE Energy money.
- Environmental justice coalitions, consumer groups, and clean energy advocates are growing frustrated with DTE Energy's utility service, political advocacy, and high rates.
- Lawmakers and regulators are under scrutiny for their unwillingness to advance certain policies aimed at helping consumers.

Michigan lawmakers facing mounting pressure to rein in DTE Energy lambasted the utility for days-long power outages in August and urged regulators to strike down its 8.8% electric rate increase request. But campaign finance records reveal DTE's tight grip on state officials, who have taken \$1.26 million combined from utility-affiliated donors over the course of their political careers.

Of Michigan's 148 state senators and representatives, 138 –

almost all of them – have logged campaign contributions from DTE’s Political Action Committee (PAC), its executives and lobbyists, or both. Gov. Gretchen Whitmer leads all state elected officials with \$235,900 in donations tied to DTE, dating back to her time in the state legislature in the early 2000s. The company has bet big on Whitmer in her time as governor, even [raising money for her](#). Most recently, Whitmer accepted \$39,450 from DTE executives in a mid-July giving blitz.

Whitmer is up for re-election this November when all state House and Senate seats will also be on the ballot. DTE, along with the other monopoly utilities in the state, is overseen by regulators appointed to the Michigan Public Service Commission (MPSC) by the governor. If Whitmer wins again, she will have the opportunity to reappoint two of the three regulators she appointed during her first term, or select new members altogether.

The state legislature also has an enormous impact on DTE’s business, setting the statutory framework in which the utility and its regulators operate. In addition, state lawmakers can use their positions to investigate issues like chronic power outages, [an increasingly popular idea](#) among advocacy organizations.

But in Michigan, the path to legislative action runs through a wall of DTE cash.

“We can’t basically regulate the utilities because they’re the ones regulating us as lawmakers,” [State Rep. Yousef Rabhi, a Democrat, said earlier this year](#). Rabhi has called for a prohibition on regulated utilities contributing to state officials, and has pushed a suite of bills that require utilities to provide hourly bill credits during outages, improve transparency about outages, and expand

opportunities for the public to weigh in on utility planning.

Rep. Abraham Aiyash, a Democrat, is pursuing the legislative package alongside Rabhi. The two representatives, along with eight of their colleagues, have not accepted DTE-linked campaign money. Aiyash has publicly criticized DTE and its political machine.

“DTE makes millions on Wall Street but doesn’t invest it back in the grid. Michigan’s private utility companies care more about profit and political power than they do about keeping the actual power on,” [Ayash tweeted in late August](#), when [hundreds of thousands of DTE customers lost power](#) after a storm. For many of them, the lights stayed out for days.

Earlier this year, when he and Rabhi proposed legislation requiring utilities like DTE to compensate customers for those kinds of outages, [Ayash said](#) he hoped his legislative colleagues would “look more at their residents and less at the coffers of DTE and Consumers [Energy].”

Legislative leaders are biggest beneficiaries of DTE donations

In the legislature, DTE has funneled the most money to House and Senate leaders who have wide latitude to set a legislative agenda and scuttle bills.

The data that informed this analysis are available [here](#).

Sen. Aric Nesbitt, the Republican who presides over the Senate as President Pro Tempore, has raked in more than \$69,500 from DTE-affiliated donors during his career. As his chamber’s leader,

Nesbitt decides which legislators serve on which committees – a key consideration for utilities whose business is molded by state law in many ways.

Sen. Ken Horn, a Republican who previously chaired the House Energy and Technology Committee and is currently vice chair of the Senate Energy and Technology Committee, has taken \$53,250 from DTE-affiliated donors during his time in office. The Senate energy committee's current chair, Republican Dan Lauwers, has received \$25,400 from DTE-affiliated donors.

These committees cover energy and utility issues, and their leaders have discretion over which bills can get hearings and ultimately advance to a vote. If committee chairs do not allow a hearing on a bill, there is no opportunity for legislators to take action on it. That is a familiar frustration for clean energy and consumer advocates who have frequently been at odds with energy committee leaders. DTE continues to [fight bills](#) that would remove [Michigan's arbitrary cap on distributed solar](#). In addition, the utility [has consistently opposed proposals for a more ambitious renewable energy standard](#) in Michigan, even though such measures are major drivers of renewable energy expansion.

Speaker of the House Jason Wentworth, a Republican, is among DTE's top beneficiaries in his chamber, with \$46,950 in DTE-tied donations. Like Nesbitt, he sets committee rosters and chose Rep. Joe Bellino, [a DTE darling](#), to return as chair of the influential House Energy Policy Committee. Bellino has logged \$36,820 in DTE-linked contributions over his career, and the utility has even [paid for him to play golf](#) with professionals at a PGA tournament. In past sessions, Bellino has aligned with DTE in refusing to allow his committee to vote on legislation that would have lifted the cap

on distributed generation.

Other notable legislators who have raked in significant campaign money from DTE donors include Senate Minority leader Jim Ananich, a Democrat, who is behind only Nesbitt with \$67,950 in related contributions. House Democratic Leader Donna Lasinski has raked in \$50,300 from DTE-linked donors during her time in office.

Nearly every member of [Senate leadership from both parties](#) has taken DTE-connected campaign contributions, for a total of \$291,940. All except one, Democratic Sen. Rosemary Bayer, received thousands of dollars – and in many cases, tens of thousands of dollars. Bayer returned the single \$250 donation she received from DTE’s PAC in 2019 and hasn’t logged any other DTE contributions.

[House leadership members](#) have also accepted money from utility-linked donors, adding up to \$111,800. Rabhi, who has [forcefully criticized DTE](#) in his time as Democratic Floor Leader, stands apart from his colleagues. He returned \$400 in total donations DTE’s PAC made to his campaign in 2017 and 2019, and hasn’t received any other DTE-related contributions.

“I’ve been in office for six years now. I have introduced dozens of bills to try to expand solar energy in Michigan, stop climate change, expand our renewable energy portfolio, and every single one of those bills has been blocked – not by magic, not by some external alien force coming in, it’s DTE,” Rabhi testified at a recent public hearing on DTE’s proposed rate hike. “It’s DTE, it’s Consumers [Energy], it’s their lobbyists on the tiles in the hallway calling legislators up, telling them they have to take their names off

my bills.”

DTE under fire for major rate hike, persistent outages

Two summers in a row, DTE customers have suffered lengthy outages that risked their health and safety. [Data show](#) Michiganders pay the highest rates in the Midwest region, but their utility service is among the most unreliable.

After widespread outages plagued DTE customers in the summer of 2021, lawmakers bowed to public pressure to investigate the problem. In the weeks before a House committee held hearings on the matter, [11 of 16 committee members received campaign contributions](#) from utility-affiliated PACs, according to a Detroit News analysis. DTE’s PAC gave six of those legislators \$1,000 apiece five days before one of its executives appeared before the body.

“DTE couldn’t do this to our communities if the regulators or the elected officials didn’t let them,” OT Goree, a DTE customer and member of the social justice group Emergent Justice, [said in April](#).

Public anger with DTE escalated to new heights in August when the MPSC, the state’s utility regulator, held a first-of-its-kind public hearing on DTE’s request to raise rates by 8.8%. Community members [jammed the hearing room](#), and commissioners had to cut off spoken testimony after it ran well over the allotted two hours. All but a handful of speakers voiced opposition to the rate hike. Several dozen DTE customers have also [filed written comments](#), almost all deriding the proposed rate increase.

Several elected officials testified at the public hearing, including

U.S. Rep. Rashida Tlaib, who represents the Detroit area that houses DTE customers most besieged by outages and low-income communities already struggling with their utility bills.

“What does DTE do when it’s not shutting people off or failing to fix outages? They’re jacking up your rates. Since 2015, DTE rate increases generated \$774 million, the second highest rate of increase of any investor-owned utility in the country,” the congresswoman wrote in [a Twitter thread that dovetailed with her spoken remarks](#). “DTE Energy is one of the most expensive and unreliable utility companies in the nation. They need accountability, NOT another rate hike that puts the lives of millions in danger,” the thread continued.

Tlaib also noted that DTE’s prolific political giving has reached almost all Michigan House and Senate members, [calling it “disgusting.”](#)

Michigan regulators will decide on DTE’s rate case in November. The proceeding has brought unfamiliar visibility to the MPSC, whose ordinarily low-profile work rarely draws a spirited audience. But as frustration grows with chronic outages, [lagging infrastructure updates](#), and rising bills in DTE territory, the regulatory body is under pressure to prioritize the captive customers bound to DTE. While MPSC members have been supportive of expanded public engagement in DTE’s rate case, some Michigan advocates are skeptical about how far the MPSC is willing to go to hold utilities accountable more broadly.

Aside from the rate case, groups like the Michigan Citizens Utility Board (CUB) negotiated for nearly two years over a \$2-per-hour outage credit and bigger payouts for customers who face longer,

more destructive service interruptions. CUB also called for stricter rules that disallow utilities like DTE from later recovering those expenses from their customers – an approach similar to that in legislation proposed by Rabhi and Aiyash. But in issuing its order earlier this year, the MPSC tilted toward the status quo. Regulators increased a flat-rate credit to \$35 per day for customers who experience prolonged outages under certain conditions, while leaving other issues murkier.

“The MPSC seems to dismiss without, even respectful consideration, arguments put forth by intervening groups like CUB that are trying to represent the public, especially when those arguments collide with the financial interests of utilities,” [CUB wrote in its rundown of the decision](#).

DTE regularly tells its shareholders that it is “[operating in a highly constructive regulatory environment](#).”

DTE political contributions undermine racial equity, climate justice

DTE’s critics say that the company’s political influence contrasts with DTE’s public-facing commitments to advance racial equity. In [testimony](#) filed with the MPSC in the rate case, intervenor Jackson Koeppel – former executive director of [the nonprofit Soulardarity](#) – noted DTE’s support for politicians pushing bills that would erode voting rights of Michiganders in predominantly Black communities and other communities of color.

Attacks on the democratic process in Michigan sparked [a campaign led by the Defend Black Voters Coalition](#). The coalition has called for corporations, including DTE, to halt campaign

contributions to the dozens of Republican state lawmakers who support voter suppression legislation.

“While these companies are happy to spew empty words that make them sound like they’re for the people, it’s far more important to them to put politicians in office that will put corporations over people and keep the rich rich,” Ken Whittaker, executive director of the Michigan People’s Campaign, [said earlier this year](#). “And they don’t care what it takes — even if it means sacrificing the freedom to vote for our community. As working families, we’re fighting back.”

[A report on “utility redlining” published in August](#) by We The People, Soulardarity, and the Michigan Environmental Justice Coalition showed that DTE has long delayed basic infrastructure improvements in low-income communities and communities of color, where system cable is commonly more than two decades past its useful life. The consequences of the utility’s inaction continue to play out in real time as those communities grapple with persistent outages and increased vulnerability to extreme weather events fueled by climate change.

“DTE’s political funding dovetails neatly with DTE’s disinvestment in BIPOC communities, making it harder for those most affected by DTE to respond,” [Koeppel wrote in DTE rate case testimony](#). (BIPOC refers to Black, Indigenous, and people of color.)

Figure 1 shows DTE Electric's Southeast Michigan service territory and how the infrastructure is past expected use in the 4.8 kV areas.

Table 1 shows DTE Electric serving customers with outdated infrastructure in service territories that have higher percentages of BIPOC and people experiencing poverty. This contributes to lower reliability, longer restoration times, and downed wires, according to the We The People [report](#).

DTE also using dark money to influence Michigan politics

Beyond making direct contributions to lawmakers' campaign funds, DTE uses dark-money groups [and its foundation](#) to reward politicians and community leaders for supporting its agenda. For example, [Michigan Energy First](#) – a front group run by several DTE executives – has invested heavily in state politics. In 2019 alone, [the Detroit News found](#) that the group gave \$650,000 to a fund tied to the Michigan Republican Party, \$250,000 to a fund connected to the Michigan Democratic Party, and \$100,000 to a fund that had supported Whitmer. It gave another \$20,000 to an organization affiliated with the wife of Wentworth, the House Speaker, according to the Detroit News report.

Another DTE-connected front group, [Protect Our Values](#), emerged this year. Under that name, DTE ramped up its support for Bellino by creating a website to praise him ahead of the Republican primary. Bellino edged out his challenger in the August election to secure his place on the ballot, and potentially his continued committee leadership, in November. DTE has also used its dark-

money groups to [spread misleading information on pro-solar legislation](#).

“DTE pursues ‘safe, reliable, clean, and cost-effective electric service’ only to the extent that regulation and popular or political pressure would otherwise limit its pursuit of maximum profits,” [Koeppel wrote in recent DTE rate case testimony](#). “And DTE seeks to limit the degree to which regulation and popular or political pressure can force it to prioritize the public interest over its own profits.”

Methodology

For this analysis, the Energy and Policy Institute reviewed campaign finance records filed from January 2006 through August 2022. This time scope is designed to cover the legislative careers of current state lawmakers, who are bound by term limits that allow them to serve a maximum of two four-year terms (for a total of eight years) in the Senate and three two-year terms (for a total of six years) in the House. This analysis included an additional five years of review for Whitmer, who served in the state legislature before she was elected governor. Contributions returned by candidates were removed from totals.

DTE PAC contributions made from January 2006 through August 2022 are available [here](#).

Campaign contributions made by DTE employees are listed in [spreadsheets provided by the Michigan Secretary of State’s Office](#).

The Energy and Policy Institute pulled from this data all contributions made by donors who identified as employees of entities whose names include “Detroit Edison” and “DTE” between

January 2006 and August 2022. Removed from giving totals were contributions from DTE employees whose titles do not suggest they are executives or lobbyists. The analysis examined contributions dating back to 2001 for Whitmer.

Update (March 2, 2023): The Energy and Policy Institute has updated its data showing DTE-linked campaign contributions after Michigan's November 2022 election, which prompted significant turnover in the Michigan House and Senate. The latest data reflects contributions made by DTE's PAC as well as its executives and lobbyists to current Michigan legislators and three statewide officeholders: Governor Gretchen Whitmer, Attorney General Dana Nessel, and Secretary of State Jocelyn Benson. It removes lawmakers who served last term but are no longer in office, either because they did not run or lost their reelection bids in November.

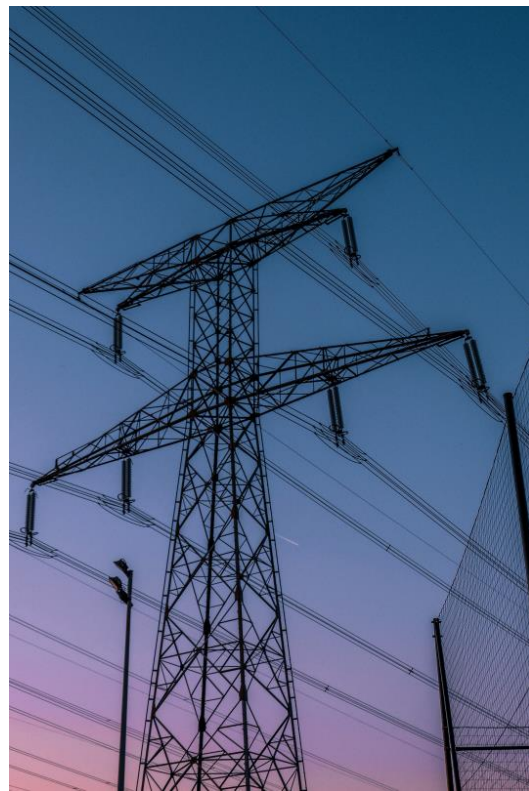
This update draws from the same required state campaign finance disclosures that informed the original analysis outlined in the Methodology section. It includes contributions made through the end of 2022, the most current information available.

The data that informed this updated analysis are available [here](#).



STRINGS ATTACHED

How utilities use charitable
giving to influence politics and
increase investor profits



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How utilities use charitable giving to influence politics and increase investor profits

December 2019

The Energy and Policy Institute is a watchdog organization working to expose attacks on renewable energy and counter misinformation by fossil fuel and utility interests. It does not receive funding from for-profit corporations or trade associations.

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DTE Energy

DTE Energy is a utility holding company with natural gas, electric, and pipeline business segments. The company serves 2.2 million electric customers and 1.3 million natural gas customers in Michigan.

Basic Facts:

- 1. EPI estimate of DTE's total charitable giving in most recent 5 years (2013-2017):** \$78,420,180²⁵
- 2. Name of Foundation:** DTE Energy Foundation
- 3. DTE Energy Foundation Giving (2013-2017):** \$66,248,118
 - a. 2017: \$15,397,171
 - b. 2016: \$14,928,082
 - c. 2015: \$14,351,630
 - d. 2014: \$11,288,231
 - e. 2013: \$10,283,004
- 4. Corporate Charitable Giving (2013-2017):**²⁶
 - a. Sum of total corporate charitable giving according to annual Corporate Citizenship report: at least \$70,000,000.²⁷
 - i. 2017: Not reported
 - ii. 2016: \$15,000,000
 - iii. 2015: \$18,000,000
 - iv. 2014: \$27,000,000
 - v. 2013: \$10,000,000
 - b. Sum of total charitable giving in most recent 5 years according to filings with the Michigan Public Service Commission: \$12,172,062.²⁸
 - i. 2017: \$1,986,893
 - ii. 2016: \$3,905,494
 - iii. 2015: \$2,017,096
 - iv. 2014: \$1,502,397
 - v. 2013: \$2,760,182
- 5. DTE Energy Foundation President:**
 - a. Lynette M. Dowler. Dowler reports to Nancy Moody, Vice President of Public Affairs for the utility. Dowler previously served as Director of Corporate Safety, Plant Director for Fossil Generation, and director of Enterprise Performance Management.
- 6. DTE Energy Foundation Board of Directors:**
 - a. Nancy Moody, Chair and Director, DTE Energy Vice President of Public Affairs

²⁵ Estimate based on DTE Energy Foundation's 990 giving and the DTE's reporting to the Michigan Public Service Commission.

²⁶ This amount of money is in addition to the money DTE Energy allocates to the DTE Energy Foundation.

²⁷ The CCR reports do not provide specific amounts. The CCR reports also not specify Foundation or corporate charitable giving.

²⁸ FERC Form 1 filings show a total of \$40,957,058 during this time period, but this total includes money allocated towards corporate sponsorships with Palace Sports and Entertainment, according to the more detailed reports filed with the Michigan Public Service Commission. EPI analyzed the PSC reports and found \$12,172,062 in corporate charitable giving, which excludes the sponsorships for entertainment events and money allocated to the DTE Foundation, between 2013-2017 (2017: \$1,986,893; 2016: \$3,905,494; 2015: \$2,017,096; 2014: \$1,502,397; 2013: \$2,760,182).

- b. Lynette Dowler, President and Director
- c. Mark Rolling, Treasurer and Director, DTE Energy Vice President and Chief Accounting Officer
- d. Joann Chavez, Director, DTE Energy Senior Vice President, Deputy General Counsel and Chief Tax Officer
- e. Trevor Lauer, Director, DTE Energy President and Chief Operating Officer
- f. David Meador, Director, DTE Energy Vice Chairman and Chief Administrative Officer
- g. Lisa Muschong, Director, DTE Energy Vice President, Corporate Secretary and Chief of Staff
- h. Bruce Peterson, Director, DTE Energy Senior Vice President and General Counsel
- i. David Ruud, Director, DTE Energy Senior Vice President, Corporate Strategy and Development
- j. Mark Stiers, Director, DTE Energy President and Chief Operating Officer DTE Power and Industrial and Energy Trading

Examples of DTE using charitable giving to manipulate policy:

2019 Integrated Resource Plan

On June 20, dozens of people gathered in a community room at the Wayne County Community College downtown campus for over four hours. Nearly everyone in the room was there to voice their displeasure with their electric utility company, DTE Energy, and its recently filed Integrated Resource Plan.

Ratepayers and citizens of Detroit told DTE Energy's regulators on the Public Service Commission that they wanted their power company to move more aggressively towards solar energy, stop planning to build more power plants that burn fracked gas, open up bidding for third parties to construct cheaper renewable energy projects, and allow more homeowners to install rooftop solar.

Yet several individuals who made public comments voiced their support for the company and its IRP.

The first speaker at the public hearing was Jane Garcia of Latin Americans for Social and Economic Development.

"Climate change must be combated, but we need to make it transparent for everyone, and that's why we need to stress the most vulnerable population and how they're going to service them. I appreciate DTE's focus in this area," stated Garcia. "I'm not sure how solar is going to come out, we only had 78 days of sunshine last year..."

Later in the evening, Reverend Horace Sheffield, a pastor at New Destiny Christian Fellowship and a leader with the Detroit Association of Black Organizations (DABO) told the commissioners, "As climate change fuels the needs for cleaner energy resources, the need for affordable energy bills remains an important factor for DTE as ever. The plan provides a communal solution to the problem of making strategic investments in renewable energy. DTE's plans gets us where we need to be in mitigating climate change without burdening our community with unreasonable electric bills."

Months later, Rev. Sheffield authored a letter to the editor in Michigan Chronicle in which he echoed is remarks at the event:

“Reliable and affordable energy fuels the engine of progress, which is why New Destiny Christian Fellowship supports DTE’s commitment to clean energy as outlined in its Integrated Resource Plan, and encourages others to do the same ... DTE’s plan gets us where we need to be in mitigating climate change without burdening our community with unreasonable electric bills.”

Rev. Deidric Tupper of New Faith Temple Church of God in Christ said, “I am 100 percent in agreement with the proposal that DTE Energy has provided. We must understand that there should be a diversity of energy. We can not always depend on wind turbines, nor can we always depend on solar energy, but natural gas stabilizes the system and allows us to be able to depend upon an institution that we have to depend upon.”

Of the 50 individuals who provided public comments, nine voiced support for DTE Energy. However, almost every DTE supporter was in some way connected to the company, including five speakers who represented charities or churches that collectively had received at least \$578,500 from the DTE Energy Foundation since 2013.

Table: DTE Energy Foundation contributions (2013-2017) to organizations and individuals who have voiced support for the company’s 2019 Integrated Resource Plan

Arab Chaldean Council	\$258,000
Detroit Association of Black Organizations, Rev. Horace Sheffield	\$112,500
Detroit Chamber of Commerce/Detroit Chamber Foundation	\$48,000
Latin Americans for Social and Economic Development	\$130,000
New Faith Temple Church of God in Christ, Deidric Tupper	\$30,000



Photo: DTE Energy Chairman Gerry Anderson (left) and Reverend Deidric I. Tupper (right). Source: New Faith Temple Facebook Page, June 5, 2019.

One audience member caught on to DTE’s relationship to those speakers that were voicing their support for the IRP. Antonio Cosme, an educational coordinator for the National Wildlife Federation, was one of the last members to speak in front of the commissioners and said, “It’s pretty obvious that DTE funds a lot of stuff in the city, so I think you’re going to get a lot of folks speaking for our monopoly energy provider. But generally speaking, most citizens of the city and of Wayne County aren’t going to speak up for DTE.”

The PSC will rule on DTE’s IRP in early 2020.

2018-2019 Rate Case and Rooftop Solar Proposals

Acting in accordance with new legislation, the rate increase that DTE Energy submitted in 2018 included a proposal to replace net metering with a new compensation program for solar customers. The proposal would have significantly reduced the rate at which a customer would be compensated for the electricity their solar panels send back to the grid, and added a fee on customers who install rooftop solar.

As with utility rate cases, intervenors provided testimony and commission hearings occurred throughout the rest of 2018 and 2019.

The public also weighed in.

Commissioner Sally Talberg said the thousands of comments urging the PSC to reject DTE’s proposed fee and reduced rate for solar compensation were “unprecedented” during her time at the agency.

In response, the utility mobilized non-profit organizations to create the perception of public support for the anti-rooftop solar proposals.

Midwest Energy News reported that a group called Michigan Energy Promise emerged in January 2019 to back DTE Energy’s position on net metering and other issues before the PSC.

On February 26, Bishop W.L. Starghill, Jr, a member of the new group and the Michigan Democratic Black Caucus, authored an opinion piece in Bridge Magazine attacking the solar industry with various utility industry talking points. Starghill said Michigan Energy Promise was created to defend the state’s energy policies.

The allies listed on Michigan Energy Promise’s website are mostly churches, chambers of commerce, and nonprofits that advocate for communities of color. However, many of the groups have either received thousands of dollars from the DTE Energy Foundation over the past five years, list the utility as a corporate sponsor on organization websites, or include a utility employee as a member of the board.

Table: DTE Energy Foundation (2013-2017) contributions to member organizations and individuals of the Michigan Energy Promise coalition

Amandla Community Development/Fellowship Chapel	\$100,000
Arab Community Center for Economic and Social Services	\$150,000
Black Family Development	\$47,500
Council of Asian Pacific Americans	Four members of its advisory board are DTE Energy employees
Detroit Association of Black Organizations, Rev. Horace Sheffield	\$112,500
Detroit Cristo Rey High School	\$29,000
Latin Americans for Social and Economic Development	\$130,000
New Faith Temple Church of God in Christ, Deidric Tupper	\$30,000
Urban League of Detroit and Southeast Michigan	\$31,500

Michigan Energy Promise’s advocacy did not result in a victory. The PSC listened to the public and rejected DTE’s proposal to raise fees on solar customers, and the PSC did not agree with the inflow/outflow method

DTE proposed. Instead, solar customers will see a larger bill credit for their excess solar energy than DTE's proposal would have allowed.

energyandpolicy.org

Michigan Energy First

12–14 minutes

Michigan Energy First is a 501(c)(4) dark money group run by several DTE Energy executives that anchors a network of front groups affiliated with the utility. Michigan Energy First has steered millions of dollars into [funds affiliated with state officials](#) and into [advertising campaigns](#) designed to influence state elections and policy decisions.

According to its required annual tax filings, Michigan Energy First has [received](#) over \$51 million in contributions since 2014. Unlike Consumers Energy and other utilities, DTE Energy does not report to shareholders its contributions to 501(c)(4) organizations.

[DTE Energy](#) is Michigan's largest investor-owned monopoly utility, with 2.3 million electric customers and 1.3 million fossil gas customers. The utility has long been a political force, and has recently [escalated its political spending](#) as it faces growing public scrutiny over poor service, high rates, and ailing infrastructure. This strategy extends to Michigan Energy First, which in 2022 made its single-largest contribution in nine years of existence: a \$1.1 million infusion to the 21st Century Fund, which is linked to the Michigan Democratic Party, [as reported by the Detroit News](#).

The big-ticket donation came as Michigan Democrats swept 2022 state elections to win control of both legislative chambers and the

governor's office for the first time in four decades – with a [campaign promise to overhaul energy laws](#). In addition to its record-setting gift to the Democratic party fund, Michigan Energy First also targeted the state's most powerful Democrat: Governor Gretchen Whitmer. [Per the Detroit News](#), it was the single-largest donation Michigan Energy First had ever made to a fund tied to a single officeholder.

Following their sweeping victory in the 2022 elections, Democratic lawmakers in 2023 ultimately passed a suite of energy bills – but not without criticism that they were [too deferential to utilities](#) and [loosened bill language](#) to appease utility interests. A DTE spokesperson did not respond when asked by the Detroit News “whether DTE believed it was appropriate for the large expenditures to benefit lawmakers who are now considering rewriting state energy laws.”

Michigan Energy First has recently favored Democratic politicians, but is not exclusively focused on that party. The dark money group reported giving \$300,000 to the Republican State Leadership Committee in 2022. Michigan Energy First also made headlines when [a report published by Planet Detroit and the Guardian](#) exposed its \$100,000 donation made in 2020 – amid the COVID-19 pandemic – to a separate dark money group that bankrolled the Unlock Michigan campaign to end Whitmer's pandemic safety restrictions.

Art Reyes, executive director of We The People MI, a consumer advocacy group that campaigns for utility industry reform, said the move functionally blocked a utility shutoff moratorium, as pursued in other states during the early stages of the pandemic. “The governor's emergency order powers were a threat,” [Reyes said](#).

“To me, it seems like DTE was inoculating against being forced to do the right thing.”

Its 2022 tax filing says [the mission of Michigan Energy First](#) is to “educate legislators and the general public on the issues facing Michigan, and to advocate.” Michigan Energy First board member Eric Doster – an attorney who has dozens of listed affiliations with political and 501(c)(4) groups in Michigan – [told the Detroit News](#) that Michigan Energy First has disbursed funds in a “deliberately non- and bipartisan manner” over “many years.”

Michigan Energy First reported \$4,661,422 in “program service expenses” in [its 2022 tax filing](#) – an uptick compared to the \$3,385,027 reported [for 2021](#), which was not an election year. The 2022 total includes \$2,410,000 distributed to other organizations, including 501(c)(4) nonprofits, and separately notes \$1,677,422 in political contributions. The overall sum also encompasses \$128,500 spent on lobbying plus \$385,500 for advertising and promotion.

As a 501(c)(4), Michigan Energy First is not required to provide a detailed breakdown of all expenses. In addition to less rigorous reporting requirements, 501(c)(4) groups like Michigan Energy First can also delay public visibility into their spending. The 501(c)(4) tax filing schedule means that the public will not be able to see funds raised or spent by Michigan Energy First in 2023 until 2024. Its activities for 2024 – the current election year – will not be disclosed until 2025.

Michigan Energy First 990s: [2022](#), [2021](#), [2020](#), [2019](#), [2018](#), [2017](#), [2016](#), [2015](#), [2014](#).

Ties to DTE Energy

A 2023 annual report filed with the Michigan Department of Licensing and Regulatory Affairs lists Michigan Energy First's board president as [Andy Colouris](#), who is DTE's vice president of corporate and government affairs. Colouris replaced former president Renze Hoeksma, a former DTE lobbyist who [retired in 2022](#) after four decades with the utility.

The board's treasurer is Theresa Uzenski, a [manager of regulatory accounting at DTE](#) and [treasurer of DTE's political action committee](#), which [makes campaign contributions](#) to candidates. Also on the board is Frank Fountain, who [also served on DTE's board](#). Other current Michigan Energy First board members include a pair of former Republican state lawmakers, Mike Nofs and Ken Sikkema. Rounding out the board is Eric Doster, an attorney who has affiliations with dozens of political and 501(c)(4) groups in Michigan, according to state records.

Dark money groups act as a smokescreen for DTE's agenda

Michigan Energy First is not the only entity through which DTE marshals dark money influence.

The Michigan Department of Licensing and Regulatory Affairs database [reveals](#) a series of assumed names for Michigan Energy First: [Alliance for Michigan Power](#), [Michigan Energy Promise](#), MI Energy Promise, and [Protect Our Values](#). These organizations – which have been active in state politics and policy discussions – appear to be coordinating as a single entity under the Michigan Energy First umbrella, linking them all to DTE.

DTE Energy spokesperson Peter Ternes previously [told Midwest Energy News](#) that DTE is “part of the Alliance for Michigan Power coalition,” and Hoeksema and Uzenski “serve in an advisory capacity” on the organizations’ boards “to provide information” about issues.

[According to Midwest Energy News](#), Michigan Energy Promise supported DTE Energy’s position on net metering and other issues before the Michigan Public Service Commission. An archived page of DTE Energy’s [www.journeyto80.com](#) website pointed visitors to take action with Alliance For Michigan Power to “stay informed and involved in the energy debates that affect all of us.”

Alliance for Michigan Power has served as a platform for DTE to assert its political agenda during key policy fights in Lansing.

In one 2021 example, the group [ran a social media ad campaign](#) criticizing efforts to lift a cap on distributed generation that limited rooftop solar in Michigan. The ads included misleading claims about solar and its costs, made without evidence. The campaign, which urged viewers to sign petitions in support of DTE’s preferred policy outcome, launched just before a potential vote on the

measure.

More details on Alliance for Michigan Power are available [here](#).

DTE-affiliated groups are most active in Michigan, but these tactics have spread as far as California.

In 2022, Michigan Energy First was linked to yet another 501(c)(4) group, the Clean and Sustainable Energy Fund (CASE). [The Los Angeles Times reported](#) then that CASE had received \$3 million from Michigan Energy First, then directed a portion of it to a foundation affiliated with a Department of Energy national laboratory in California. That laboratory then pushed California policymakers to support carbon capture and sequestration, a controversial and unproven technology that DTE plans to use at several biomass plants it owns in the state despite objections from environmental justice groups.

Election season activity

Other efforts by the Michigan Energy First network have focused more explicitly on election outcomes. The newest addition, [Protect Our Values](#), surfaced just in time for the 2022 campaign season to support Republican State Rep. Joe Bellino, who was then chair of the House Energy Committee and one of the fiercest utility advocates holding office. Bellino played a key role in fending off policies DTE didn't support, including bills aimed at lifting the cap on distributed generation – a proposal that effectively stalled when he refused to allow his committee to vote on it.

While 501(c)(4) groups like Michigan Energy First and its affiliates are prohibited from campaigning “on behalf of or in opposition to any candidate for public office” the groups are allowed to [engage in some political activities](#), but not as their “primary activity.” The

501(c)(4) groups operating in Michigan tend to skirt around that restriction with milquetoast praise for a candidate on broad issues, such as when Protect Our Values' ads [billed Bellino](#) "a champion for Michigan's small business."

Cultivating community voices

Michigan Energy Promise, which is connected to Michigan Energy First, was active in 2019 and 2020, and was advocating for a reduction in the amount customers are paid for their solar power, an issue DTE was contesting with utility regulators. [Grant documents](#) reveal that the organization exists to "educate and engage local communities and our leaders in Lansing on smart policy solutions." It intended to perform "person-to-person engagement" through canvassing, prayer breakfasts, block parties, and community events. The group [targeted](#) low-income customers, non-English speaking customers, people in public education and safety, people with disabilities, seniors, and union members in its campaign.

Organizations listed on Michigan Energy Promise's since-deleted "allies" webpage are mostly churches, chambers of commerce, and nonprofits that advocate for communities of color. (An archived page from February 2020 is [available here](#).) Many of the organizations either [received money from the DTE Energy Foundation](#), listed the utility as a corporate sponsor on their websites, or included a utility employee as a member of their board.

Michigan Energy Promise also wanted to use media initiatives, such as earned media, to reach its "targeted audience." Former Michigan Public Service Commissioners [John Quackenbush](#),

[Monica Martinez](#), and [Steven Transeth](#), along with [Bishop W.L. Starghill, Jr.](#) of the Michigan Democratic Black Caucus, wrote pieces that defended DTE's energy policy proposals. In his, Starghill Jr. mentioned that he is a member of Michigan Energy Promise.

More details on Michigan Energy Promise are available [here](#).

Calls for transparency

In 2023, DTE executives and shareholders [voted down a proposal](#) that would have required the utility to detail corporate dark money spending, brought forward by a group of DTE shareholders who noted growing public backlash against DTE's political influence machine. [The measure](#) would have forced greater transparency into dark money spending on lobbying and 501(c)(4) groups. It specifically called out Michigan Energy First, noting that DTE "critically fails to disclose its payments" to the group.

Michigan Attorney General Dana Nessel has also [called for greater transparency](#) into utilities' political spending generally, including activities related to 501(c)(4)s. While Michigan utility regulators have not incorporated key recommendations she's made that would boost visibility into dark money spending, Nessel's office in 2023 secured [a first-of-its-kind disclosure requirement](#) for DTE as part of a settlement agreement that resolved a broader regulatory proceeding.

The provision requires that DTE, starting in October 2024, publish to its website annually a report that shows contributions that DTE entities made to recipients including 501(c)(4) groups for the prior year ending August 31.

Assessing the State of Environmental Justice in Michigan

by

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**A report submitted
in partial fulfillment of the requirements
for the degree of
Master of Science
School for Environment and Sustainability
University of Michigan
May 2019**

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Client: Michigan Environmental Justice Coalition**

Abstract

This study sought to address the research question, “What is the state of environmental justice in Michigan?” In doing so, the team addressed the feasibility of creating a publicly available, accessible Michigan-specific screening tool that would display environmental, social, and health data relevant to environmental justice. This research had two main components: one qualitative and one quantitative. Qualitative methodology involved conducting semi-structured, in-depth interviews with thirty environmental justice leaders in the state of Michigan. Quantitative methodology involved comparing the data and methodologies used in the US Environmental Protection Agency’s (US EPA) EJScreen, California Environmental Protection Agency’s (CalEPA) CalEnviroScreen, and Minnesota Pollution Control Agency’s (MPCA) Story Map and What’s in My Neighborhood screening tools. Publicly available social and environmental data from the US Census Bureau, US Department of Housing and Urban Development, and US EPA were spatially and statistically analyzed according to CalEPA and MPCA’s methodologies. A map incorporating best practices from both agencies was created and uploaded onto ArcGIS Online to demonstrate the feasibility of creating a Michigan-specific screening tool. Results of this research demonstrate that environmental harms and goods are not equitably distributed throughout Michigan, that developing a Michigan-specific screening tool is feasible and desired, and that a screening tool must be accompanied by strong state-level policy addressing environmental justice. This study contributes to the understanding of vulnerable communities in the state, and serves as a baseline to which progress in environmental justice can be measured.

Acknowledgements

We would like to acknowledge and sincerely thank the many individuals who made this project possible. Dr. Paul Mohai of the University of Michigan School for Environment and Sustainability provided support, guidance, feedback, and extensive knowledge of the environmental justice movement and discipline throughout our research process. We sincerely thank Michelle Martinez, Coordinator of the Michigan Environmental Justice Coalition (MEJC), along with the coalition members for partnering with us in this research and for the incessant and tireless work they devote to advancing environmental justice in Michigan.

We would also like to thank Shankar Prasad and Walker Wieland, both of CalEPA, for their technical assistance and review of our methodology for adapting CalEnviroScreen to a Michigan-specific environmental justice screening tool.

Dr. Paige Fischer of the University of Michigan School for Environment and Sustainability supported and guided the development of the interview guide and methodology for data analysis used in the qualitative component of this project. The staff of the Office of Academic Programs worked hard to ensure we had the logistical support we needed.

Finally, we would like to sincerely thank the thirty environmental justice leaders in Michigan who allowed us to interview them for this report. We are grateful for their time and for their providing us a window into their lives and experiences.

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Chapter 1. Introduction

Environmental justice, which connects the distribution of environmental harms to social characteristics, is both a field and movement. This connection has gained national attention in the last several decades through cases such as hazardous waste siting in predominantly African American Warren County, North Carolina; Hurricane Katrina in New Orleans; the Dakota Access Pipeline in the Standing Rock Indian Reservation; natural gas extraction through fracking in West Virginia; and most recently the Flint Water Crisis, all of which involve environmental harms disproportionately burdening communities that have low socioeconomic status or are predominately racial or ethnic minorities (Lee 2011; Jacobs-Shaw 2017; Bienkowski 2015; Mohai 2018). The federal government and the government of each individual state approach environmental justice differently. This report explores environmental justice in the state of Michigan: the status of relevant issues, the approach the State takes to monitoring effects of environmental harms on vulnerable communities, and opportunities the State has to advance environmental justice.

One method used to monitor environmental injustice is mapping. This study analyzes three different approaches to mapping currently used at the federal and state levels to provide a baseline and inform the adoption of an approach specific to the state of Michigan. First, the US Environmental Protection Agency, the federal agency tasked with environmental protection, attempts to address environmental justice on a national scale. One way the agency seeks to inform the process of assessing potential exposure is through its online mapping tool, EJScreen. This tool does not inform policy, but makes environmental and demographic data available in an accessible platform for professionals and members of the public to use and analyze (EPAGroups 2016). Second, the California Environmental Protection Agency uses its online tool, CalEnviroScreen, to spatially analyze impacts of environmental harm on sensitive communities (Kuruppuarachchi 2017). CalEnviroScreen is used to inform policies, programs, and activities in the state (Faust, August, Bangia, Galaviz, Leichty, Prasad, and Zeise 2017). Finally, the state of Minnesota uses its two online spatial analysis tools, Story

Map and What's in My Neighborhood, to identify communities sensitive to environmental harm (MPCA 2018).

Environmental justice is a salient issue in Michigan both currently and historically. The Flint Water Crisis made national news when residents were poisoned by drinking lead-contaminated water in 2014, and residents of communities such as Southwest Detroit have been disproportionately burdened by industrial air pollution for years (Flint Advisory Task Force 2016; Mohai 2018; CNN Library 2019; Schlanger 2016). Activists and community leaders have been gaining momentum in the struggle against environmental harms to which locals of lower socioeconomic or minority status are disproportionately exposed. In 2010, the Environmental Justice Working Group commissioned by Governor Granholm delivered a plan for promoting the equitable distribution of environmental harms and goods in Michigan (Environmental Justice Working Group 2010). The plan was never enacted by the State. Since then, Governor Snyder convened two additional groups to investigate environmental justice in the state: the Flint Advisory Task Force in 2016 and the Governor's Environmental Justice Work Group in 2018 (Flint Advisory Task Force 2016; Environmental Justice Work Group 2018). Environmental justice in Michigan is discussed in more detail in [Chapter 2](#).

Wanting to capitalize on this momentum as well as inform advocacy channels and political activity moving forward, the Michigan Environmental Justice Coalition (MEJC) approached the University of Michigan's School for Environment and Sustainability to convene a student research team in the fall of 2017. The MEJC is a network of nonprofit organizations, academic institutions, and individual members that work towards environmental justice, community health, racial justice, and economic equality in the state of Michigan (Michigan Environmental Justice Coalition n.d.). More information on MEJC is available online at <https://michiganenvironmentaljusticecoalition.wordpress.com/>.

The MEJC submitted a formal proposal to the school with the seven following goals and objectives: (1) create and deliver an environmental justice assessment of the state of Michigan; (2) identify, gather, and assess environmental justice datasets to effectively evaluate the state of environmental justice in Michigan; (3) layer

social indicators of people of color communities and communities at and below the federal poverty line; explore vulnerable population subsets; (4) deliver a statistical analysis of cumulative environmental impacts on these communities; (5) integrate a community input aspect that may include surveys, interviews, focus groups; (6) develop a policy analysis congruent to the institutionalized implementation of solutions to the problem of cumulative impact; and (7) deliver a final report to the MEJC that communicates findings of the state of environmental justice that includes a physical rendering of the results, presentations, maps, and a glossy report. After the submission of this proposal, a team of three students formed under the advisement of Dr. Paul Mohai. In partnership with the MEJC, the research team finalized the research proposal and research plan.

This research proposal and plan addressed the overall question: “What is the state of environmental justice in Michigan?” In answering this question, the team also sought to explore the feasibility of developing a spatial analysis tool with data specific to the state of Michigan. To fulfill this broad goal, the research team employed a mixed-method approach with three main objectives. First, a comparative analysis was conducted to determine what Michigan-specific data was available to complete a statewide assessment of environmental justice. This stage involved comparing data used in several environmental justice screening tools, including those created by the US EPA, CalEPA, and MPCA. This analysis revealed what specific data could be used in an online environmental justice screening tool and whether the state already collected these data in Michigan.

Second, local perceptions and perspectives on statewide environmental justice were collected by conducting in-depth interviews with environmental justice leaders in the state, including scholars, professionals, and community activists. Through thirty semi-structured interviews, the research team gathered information on strengths and vulnerabilities of local communities, impacts of environmental injustice, and leaders’ use of advocacy tools, including those involving online spatial analysis. The team transcribed, coded, and analyzed these data.

Third, a statewide assessment of environmental justice was conducted based on empirical data available through the US EPA’s EJScreen tool, which covers the entire US. Environmental and social data specific to

Michigan was analyzed according to the methodology employed in CalEPA's CalEnviroScreen and in Minnesota's two screening tools in order to rank and display block groups in Michigan according to their environmental justice status. The results of this spatial analysis are hosted on an online platform.

This report is divided into six chapters. [Chapter 2](#) presents a literature review focused on historical and current definitions and methods of environmental justice, along with detailed information about spatial analysis tools used by the US EPA, CalEPA, and the MPCA. [Chapter 3](#) presents methodology used in the qualitative data analysis of this project. Methods for qualitative data analysis included outreach to the MEJC contact list, snowball contacts, and individuals who submitted a proposal to present at the MEJC's statewide Environmental Justice Summit that occurred in Flint, Michigan in September 2018. The team conducted thirty semi-structured interviews, and completed inductive thematic data analysis. [Chapter 4](#) presents the results of the qualitative data analysis. [Chapter 5](#) presents methodology used in the quantitative data analysis of the study. Methods for quantitative data analysis included comparing the data and methods of three sets of screening tools, accessing and preparing Michigan-specific data, and spatially and statistically analyzing Michigan-specific data according to the methodology used in CalEnviroScreen and MPCA's Story Map and What's in My Neighborhood tools. [Chapter 6](#) presents the results of the quantitative data analysis. [Chapter 7](#) discusses the implications of the results of this study. [Chapter 8](#) addresses limitations of this study and provides a conclusion to the research. The Michigan Department of Environmental Quality (MDEQ) is mentioned throughout this report. It should be noted that at the end of April 2019, the MDEQ was renamed by Governor Whitmer to the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

The team completed the research process in collaboration with the MEJC, attending meetings with the Coordinator and the the Coalition as a whole. Feedback from the Coordinator was incorporated throughout the project proposal and design process.

Chapter 2. Literature Review

This literature review focuses on four main topics: definitions of environmental justice, evidence and methods of analysis of environmental injustice, environmental justice in the Michigan context, and three spatial analysis tools used to evaluate the state of environmental justice. In discussing definitions of environmental justice from scholars and activists along with methods and evidence that leaders have used to document environmental injustice, this literature review seeks to provide a history of the issue along with its salience to the state of Michigan. This chapter examines three sets of spatial analysis tools: (1) EJScreen used by the US Environmental Protection Agency; (2) CalEnviroScreen used by the California Environmental Protection Agency; and (3) Story Map and What's in My Neighborhood, both used by the Minnesota Pollution Control Agency. By exploring these three tools and their uses by the agencies that created them, this literature review demonstrates that creating a spatial analysis tool specific to the state of Michigan would be feasible and helpful in continuing to monitor the state of environmental justice.

2.1 Definitions of Environmental Justice

Environmental justice is both a discipline and movement that has been fighting for the proportionate distribution of environmental goods and hazards since its inception in 1982 in Warren County, North Carolina when a group of Civil Rights activists protested the siting of toxic waste in a historically African American neighborhood (Mohai, Pellow, and Roberts 2009). Following this protest, a few major events took place that helped define and conceptualize environmental justice.

The protests in Warren County prompted a study by the US General Accounting Office in 1983 that found that three of four hazardous waste landfills examined were sited in areas that were majority African American and where families' incomes were below the poverty line (US GAO 1983). The protests also

prompted the United Church of Christ's (UCC) *Toxic Wastes and Race in the United States* report in 1987, which was the first national study showing that the percent of minority population in each zip code was the best predictor of the location of hazardous waste facilities in the country (UCC 1987). In 1990, Dr. Bunyan Bryant and Dr. Paul Mohai organized the Michigan Conference on Race and the Incidence of Environmental Hazards at the University of Michigan, which, combined with the UCC report, put environmental justice on the US EPA's radar (US EPA 1992). In 1990, Dr. Robert Bullard published *Dumping in Dixie: Race, Class, and Environmental Quality* where he used the civil rights movement to connect environmentalism with social justice and classified environmental justice concerns in terms of three different categories: procedural, geographic, and social (Bullard 1990). Also in 1990, the Indigenous Environmental Network was formed to build capacity of Indigenous communities and tribal governments (Indigenous Environmental Network n.d.). In 1991, the First People of Color National Environmental Leadership Summit met where attendees created and adopted the Seventeen Principles of Environmental Justice (see Figure 1) (US EPA 2017b; Bullard, Mohai, Saha, and Wright 2007). In 1992, a US EPA workgroup published *Environmental Justice: Reducing Risk for All Communities*, a report that proposed ten recommendations to address environmental justice, including creating an Office of Environmental Justice at the US EPA (US EPA 1992). Three years later in 1994, President Bill Clinton signed Executive Order 12898, which was the first federal policy to address environmental justice. In 2003, the US EPA issued a framework for cumulative impact assessment (US EPA 2017b). In 2007, the UCC's *Toxic Wastes and Race in the United States* report was updated after twenty years and it found that people of color were more concentrated around hazardous waste than previously reported in 1987 (Bullard, Mohai, Saha, and Wright 2007). More recently, in 2015 the US EPA released EJScreen, its online screening tool that layers social and environmental data for anyone in the country to access (US EPA 2017b). Each of these events and milestones has proved to be constructive in framing the goals and objectives of this research and the team's research builds upon the collective history of this movement.

There are many working definitions of environmental justice that organizations, scholars, activists, and the government employ. According to the US Environmental Protection Agency (US EPA), environmental justice is “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies” (US EPA 2019). However, environmental justice scholars, activists, and community members use many definitions and concepts of environmental justice in their research, writing, and activism efforts.

In October of 1991, the First National People of Color Environmental Leadership Summit took place in Washington, D.C. with over 1,000 participants. At this event the Seventeen Principles of Environmental Justice were developed. These principles stated that environmental justice involves policies free from discrimination, responsible uses of land and resources, universal protection from environmental hazards, self determination for all people, equal access to decision-making processes, education of present and future generations on environmental issues, and more (NRDC 2016). This summit was a milestone for the environmental justice movement based on its attendance and output of an authoritative definition of environmental justice from the perspective of affected citizens (Bullard 2007). The seventeen principles are listed below in Figure 1 (NRDC 2016).

WE, THE PEOPLE OF COLOR, gathered together at this multinational People of Color Environmental Leadership Summit, to begin to build a national and international movement of all peoples of color to fight the destruction and taking of our lands and communities, do hereby re-establish our spiritual interdependence to the sacredness of our Mother Earth; to respect and celebrate each of our cultures, languages and beliefs about the natural world and our roles in healing ourselves; to ensure environmental justice; to promote economic alternatives which would contribute to the development of environmentally safe livelihoods; and, to secure our political, economic and cultural liberation that has been denied for over 500 years of colonization and oppression, resulting in the poisoning of our communities and land and the genocide of our peoples, do affirm and adopt these Principles of Environmental Justice:

The Principles of Environmental Justice (EJ)

- 1) **Environmental Justice** affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction.
 - 2) **Environmental Justice** demands that public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias.
 - 3) **Environmental Justice** mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living things.
 - 4) **Environmental Justice** calls for universal protection from nuclear testing, extraction, production and disposal of toxic/hazardous wastes and poisons and nuclear testing that threaten the fundamental right to clean air, land, water, and food.
 - 5) **Environmental Justice** affirms the fundamental right to political, economic, cultural and environmental self-determination of all peoples.
 - 6) **Environmental Justice** demands the cessation of the production of all toxins, hazardous wastes, and radioactive materials, and that all past and current producers be held strictly accountable to the people for detoxification and the containment at the point of production.
 - 7) **Environmental Justice** demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation.
 - 8) **Environmental Justice** affirms the right of all workers to a safe and healthy work environment without being forced to choose between an unsafe livelihood and unemployment. It also affirms the right of those who work at home to be free from environmental hazards.
 - 9) **Environmental Justice** protects the right of victims of environmental injustice to receive full compensation and reparations for damages as well as quality health care.
 - 10) **Environmental Justice** considers governmental acts of environmental injustice a violation of international law, the Universal Declaration On Human Rights, and the United Nations Convention on Genocide.
 - 11) **Environmental Justice** must recognize a special legal and natural relationship of Native Peoples to the U.S. government through treaties, agreements, compacts, and covenants affirming sovereignty and self-determination.
 - 12) **Environmental Justice** affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity of all our communities, and provided fair access for all to the full range of resources.
 - 13) **Environmental Justice** calls for the strict enforcement of principles of informed consent, and a halt to the testing of experimental reproductive and medical procedures and vaccinations on people of color.
 - 14) **Environmental Justice** opposes the destructive operations of multi-national corporations.
 - 15) **Environmental Justice** opposes military occupation, repression and exploitation of lands, peoples and cultures, and other life forms.
 - 16) **Environmental Justice** calls for the education of present and future generations which emphasizes social and environmental issues, based on our experience and an appreciation of our diverse cultural perspectives.
 - 17) **Environmental Justice** requires that we, as individuals, make personal and consumer choices to consume as little of Mother Earth's resources and to produce as little waste as possible; and make the conscious decision to challenge and reprioritize our lifestyles to ensure the health of the natural world for present and future generations.
- More info on environmental justice and environmental racism can be found online at www.ejnet.org/ej/**

Delegates to the First National People of Color Environmental Leadership Summit held on October 24-27, 1991, in Washington DC, drafted and adopted these 17 principles of Environmental Justice. Since then, the Principles have served as a defining document for the growing grassroots movement for environmental justice.

Figure 1. The Seventeen Principles of Environmental Justice developed at the First National People of Color Environmental Leadership Summit in 1991.

Professor Bunyan Bryant defined environmental justice as “those cultural norms and values, rules, regulations, behaviors, policies, and decisions to support sustainable communities, where people can interact with confidence that their environment is safe, nurturing, and protective” (Bryant 1995, 6). Scholar Robert Kuehn built on definitions offered by Bryant, Bullard, and many others when he proposed a four-pronged definition of environmental justice that included distributive justice, procedural justice, corrective justice, and social justice. Kuehn distilled many of his ideas of environmental justice while analyzing the controversy surrounding the Shintech poly-vinyl chloride plant in St. James Parish, Louisiana, while he led the University Environmental Law Clinic, which tried to help affected residents in their struggle (Kuehn 2000). First, distributive justice referred to ensuring the same distribution of environmental goods and services to everyone and included both mitigating disproportionate burdens of environmental hazards placed on minority communities and ensuring equal access to benefits of environmental programs. Second, procedural justice referred to the fairness of and access to decision-making processes, which should be inclusive and represent all groups equally. All groups should agree on the process, especially those most affected by environmental actions. Third, corrective justice involved fairly punishing those who break the law and repairing the losses for people and groups who are damaged. Buyouts and relocation are common practices in seeking corrective justice but typically end up treating the community as the problem instead of the pollution (Kuehn 2000). Fourth, social justice referred to society meeting people’s needs. The lens of social justice put issues of environmental injustice in the context of broader problems of racial and economic inequalities (Kuehn 2000). Kuehn (2000) suggested that this four-part definition of environmental justice offered “a means to ensure that environmental justice concerns are appropriately integrated into environmental decision-making” as well as “the opportunity for greater awareness of what justice means to impacted people of color and lower income communities” (57).

Scholar Steve Lerner focused his writing on the effects of environmental injustice on people of specific communities. Lerner (2010) wrote about sacrifice zones, which are areas adjacent to industry or military bases where residents experience toxic chemical exposure. People living in these areas are typically minority or

low-income, and the areas were such named because residents have to make health and economic sacrifices that white and wealthier people can better avoid. According to Lerner, sacrifice zones result from inequitable and biased land use decisions whose health impacts are often not communicated to residents of affected areas, making it impossible for them to try to move or take action in a timely manner. These unjust decisions turn citizens into activists as they force residents to organize themselves, find allies, get the attention of the media, and more, all without any compensation. Lerner emphasized that community organizers in sacrifice zones must fight against huge industries with access to many more resources than they have, including corporate lawyers who can successfully argue that residents experience adverse health effects because they are poor, lack access to healthcare, have unhealthy habits, etc, all of which blame the residents instead of the toxic pollution. In addition to bringing to light the work of community organizers in sacrifice zones, Lerner discussed the challenges to industries that seek to make profit as they make difficult decisions about where to place their facilities. Lerner (2010) demonstrated industry's predicament when he said, "Thus, wherever they choose to build, they will discomfit some community" (14). Lerner pointed out that sacrifice zones in the US are hidden from the majority of citizens as they are located off the beaten path. It is important to bring attention to residents of these communities to attempt to repair damages done and bring about equity and environmental justice (Lerner 2010).

More recently, Julian Agyeman (2008) extended these earlier notions of environmental justice to the sustainability movement through the Just Sustainability Paradigm, which is the policy architecture supporting the nexus between environmental justice and sustainability. According to Agyeman, environmentalism has not dealt well with justice and equity. The dominant narrative of sustainability is that environmentalists are saving the world for everyone equally, thus there is no need to focus on social justice. However, the notion of sustainability must be transformed to address what Agyeman defined as the equity deficit, or the fact that sustainability seeks to protect unborn future generations but doesn't protect vulnerable populations alive in the

present moment (Agyeman 2008). Agyeman's work represents a new frontier of environmental justice literature that focuses on embedding justice in already existing sustainability work and narratives.

Other scholars have written about environmental justice in terms of institutional discrimination (Saha and Mohai 2005; Mohai and Saha 2006, 2007, 2015; Mohai, Pellow, and Roberts 2009), building on Feagin and Feagin's (1986) model of discrimination that moves beyond the individual prejudice of members of society. Feagin and Feagin presented discrimination as more than just individual prejudice, but also inclusive of institutional and structural facets. According to these authors, discrimination results from people's interest in protecting their own privilege and power and from internalized colonialism, which is the historical exploitation of non-European groups by European groups that has led to current institutionalized structures that continue to exploit minority groups. This discrimination routinely manifests itself in issues of both race and class. Because it is structural and institutional, it can be unintentional and indirect, with indirect institutionalized discrimination being the most neglected type. Indirect institutionalized discrimination describes practices that have a negative effect on minority groups even when norms or rules regulating those actions were designed with no prejudice behind them. Environmental injustice committed against members of minority racial groups and people of low socioeconomic status can often be the result of institutional discrimination. Further, injustices can be committed as the result of side-effect discrimination, which describes actions taken by one institution that have a negative impact on minority groups because they are directly linked to discriminatory actions of another institution (Feagin and Feagin 1986).

Forman and Lewis of the University of Illinois at Chicago have also studied the impact of indirect forms of prejudice and white racial attitudes, specifically in the wake of Hurricane Katrina. These authors described racial apathy, or indifference towards racial inequality, and white ignorance, or white people not knowing about racial inequality, as new forms of prejudice against racial minorities. White people not caring and not knowing about racial inequality were displayed in their surprised reactions to the racialized impacts of

Hurricane Katrina. According to the authors, racial apathy and white ignorance stem from color-blind discourses and are just now starting to receive attention (Forman and Lewis 2006).

2.2 Evidence and Methods of Environmental Justice Research

Scholars have documented the existence of environmental injustice using statistical and spatial methods by analyzing the location of environmental hazards and the surrounding demographics in terms of race and socioeconomic status. The first national study directly connecting the distribution of hazardous waste sites and race was *Toxic Wastes and Race in the United States* written by the United Church of Christ, which showed that minority percentage of the population in each zip code is the best predictor of the location of hazardous waste facilities in the US (United Church of Christ 1987). Much of the scholarship following this UCC report has focused on the debate surrounding whether race and class both play a role in predicting environmental injustice, and the debate about whether minority communities or polluting facilities first appear in environmental justice communities. These two questions represent two large debates of the environmental justice movement that center around figuring out whether minority communities are targeted for new facilities as paths of least resistance, or if wealthier and white residents have an easier time moving away from facilities once property values decline. These debates seek to help explain why environmental disparities exist and have political and policy implications (Mohai 2008).

In 2007, the United Church of Christ's *Toxic Wastes and Race in the United States* report was updated and once again revealed a greater concentration of people of low socioeconomic status and people of color around hazardous sites (Bullard, Mohai, Saha, and Wright 2007). According to the research presented in this updated report, 56% of people living within 3.0 kilometers of a hazardous waste facility are people of color, while people of color make up only 30% of the US population. The 2007 report also stated that annual household incomes and housing values are lower in host neighborhoods than in neighborhoods without environmental hazards (Bullard et al. 2007). This 2007 analysis used the more accurate and improved

distance-based methods of spatial analysis described and advocated by Mohai and Saha in their 2006 article (Mohai and Saha 2006).

More recently, scholars have analyzed environmental justice using longitudinal data that covers a longer term than previous studies. Mohai and Saha (2015a) sought to analyze how present-day environmental disparities came about, which required examining demographic characteristics of host sites at the time of siting and after siting occurred. The disparate-siting hypothesis refers to environmentally hazardous sites being disproportionately placed in communities where minorities or poor people live at the time of siting. The post-siting demographic change hypothesis refers to demographic changes happening after the siting of environmentally hazardous sites when minorities and people of low socioeconomic status move into host communities and more affluent whites move away. It has been difficult for scholars to reach consensus on these hypotheses thus far because most studies have been cross-sectional, snapshot studies that reflected demographic information only at one point in time, and have used differing methods and geographic scopes. However, Mohai and Saha (2015b) presented evidence from the first national longitudinal study of environmental injustice analysis using distance-based methods that supported the disparate-siting hypothesis. Furthermore, Mohai and Saha's results indicated that socioeconomic and racial disparities around hazardous waste sites widen over time, that demographic changes in communities attract environmental hazards, and that race is a stronger predictor of environmental hazard siting than socioeconomic class (Mohai and Saha 2015b). However, they also found that, rather than triggering demographic changes after hazardous waste facilities are sited, demographic changes occur even before siting, suggesting that communities undergoing demographic changes are vulnerable to the siting of new locally unwanted land uses (LULUs). This process is likely due to eroding social capital and political clout accompanying such demographic changes (Mohai and Saha 2015b).

In addition to studying who is affected by environmental hazards, scholars are examining who is polluting the environment. Collins et al. (2016) presented the first national study to analyze the scope of variations in industrial pollution alongside inequities in exposure to this pollution. With the goal of assessing

producer disproportionalities and the degree to which specific communities are disproportionately impacted by pollution, researchers used the US EPA's Risk Screening Environmental Indicators-Geographic Microdata from 2007 and data from the US Census in 2000 to evaluate the proportional contribution of polluting facilities and their relationship to variables indicative of environmental injustice. The researchers found that outliers exist in terms of disproportional pollution emissions and that low-income populations and nonwhite populations are more likely to live in areas near these top polluters. The top polluters typically display a lack of concern for disadvantaged communities. Collins et al. (2016) reported, "They found that of the 100 worst polluters, the top ten imposed disproportionate impacts on disadvantaged communities. They found that minorities living near these ten polluters were bearing more than half of the human health risk generated in the region," (3). These results might mean that it is possible to dramatically improve environmental quality simply by regulating the top industrial polluters (Collins et al. 2016).

2.3 The Michigan Context

The environmental justice framework and methodology is especially relevant to recent events and efforts in Michigan. In 1990, Dr. Bryant and Dr. Mohai organized a conference to bring together researchers in the US studying the spatial distribution of environmental hazards and accompanying racial and socioeconomic disparities (Mohai 2008). The 1990 Michigan Conference resulted in a series of meetings between the US EPA and representatives of the Michigan Conference, later dubbed by the US EPA as the "Michigan Coalition" (Mohai 2018). These meetings, which were broadened to include other environmental justice leaders across the US, resulted in the creation of the Office of Environmental Justice in the US EPA, the National Environmental Justice Advisory Council (NEJAC), and the publication of US EPA's 1992 report *Environmental Equity: Reducing Risks for All Communities*. The latter represents the first acknowledgement by the federal government that environmental injustices exist and that government actions and policies need to address them (Mohai 2018).

In the late 1990's, community groups in Michigan filed civil rights complaints with the Office of Environmental Justice at the US EPA against permits issued by the Michigan Department of Environmental Quality (MDEQ) to Genesee Power and Select Steel in Flint, and a hazardous waste injection well in Romulus. Community groups claimed the permitting methods were discriminatory. In each case, the US EPA either did not issue a decision or found the permits were not discriminatory; however, the US EPA did encourage MDEQ to develop a policy and program to address environmental justice in the state. The agency formed a workgroup in 1998, which produced a report called *Environmental Justice Recommendations*. The recommendations were never implemented and the workgroup dissolved in 2000. The MDEQ made efforts to improve public outreach, including drafting a document called *Model Community Outreach Plan* in 2001 and asking the Environmental Advisory Council (EAC) to develop environmental justice principles for the agency. The EAC created *Recommendations for an Environmental Justice Policy for Michigan*, which the MDEQ Director and Department of Civil Rights Director submitted to Governor Jennifer Granholm in 2006 (Environmental Justice Working Group 2010).

Based on these recommendations, in 2007 Governor Granholm issued an Executive Directive addressing environmental justice. In it, Governor Granholm charged the Michigan Department of Environmental Quality and Department of Natural Resources and Environment with developing and implementing a plan to promote environmental justice in the state (Granholm 2007). The MDEQ convened the Environmental Justice Working Group, made up of representatives from state agencies, advocacy groups, academia, local tribes, and economic development and business organizations who worked for two years to develop a plan. Key elements of their plan addressed disparate impacts, integration of justice into agency activities, public participation, tribal consultation, inter-agency cooperation, and the role of local units of government (Environmental Justice Working Group 2010). The working group released their report in 2010, but according to an opinion piece published in the Detroit Free Press by two environmental justice leaders in Michigan, the State never put it into action (Turner-Handy 2016).

The state has been in the national spotlight in the wake of the Flint Water Crisis, a massive case of environmental injustice as reported by the Flint Water Advisory Task Force (FWATF) convened by Governor Rick Snyder. After emergency managers switched the Flint water supply from the Detroit water system to the Flint River in April 2014, the population of Flint, which is majority African American and low-income, was exposed to toxic levels of lead and other contaminants through the drinking water. Inadequate preparation of the staff, inadequate upgrades to the water plant, inadequate and improper sampling for water quality, disregard for evidence of water quality issues and related health effects, dismissive responses to citizen concerns, and delays in responding to evidence of exposure to water contamination all resulted in an environmental and public health disaster in Flint (Flint Water Advisory Task Force 2016). After acknowledging that an injustice had taken place, Michigan Governor Snyder assembled a task force of five members. As stated in their report, “...the magnitude of this tragedy warrants deep and detailed investigation” (Flint Water Advisory Task Force 2016, 3).

Another major environmental justice issue in Michigan is industrial air pollution in Southwest Detroit, specifically in 48217, which is often referred to as the most polluted zip code in Michigan (Lam 2010). According to a map published in a 2018 MDEQ report entitled *48217 Community Air Monitoring Project*, the 48217 zip code is surrounded by more than two dozen major industrial facilities that report air emissions to Michigan Air Emissions Reporting System (Kilmer and Williams 2018). Further, the area has more sulfur dioxide than federal standards allow, which contributes to high asthma rates of residents in the area (Schlanger 2016). Citizens continue to breathe high levels of toxic pollutants from industries such as Marathon, DTE Energy, Carmeuse Lime, and more, while officials cite difficult negotiations and major changes in operation as barriers to getting companies to reduce their emissions (Schlanger 2016). The case of industrial air pollution in Southwest Detroit received national attention when Zoe Schlanger published an article in *Newsweek* in 2016 about the health implications for residents (Schlanger 2016).

Rural and tribal communities also experience environmental injustice in Michigan. According to Potawatomi Nation member and scholar Kyle Whyte, pipelines often pose threats to both water quality on which Native communities rely, and the treaty rights which govern their land use (Balaskovitz 2017). Additionally, the mining efforts of companies threaten the health and environment of those who live nearby, especially members of Native American tribes (Bienkowski 2012). For example, the Keweenaw Bay Indian Community of the Lake Superior Band of Chippewa spent years fighting the construction of a nickel mine near land and water on which they depend. The mine near Lake Superior interferes with spiritual, provisional, and recreational uses of the land and has the potential to pollute groundwater, which would also affect local fish and aquatic species. Tribal leaders continue to advocate for their treaty rights to be honored during related decision-making processes (Bienkowski 2012).

Another case relevant to rural communities that made national news occurred in 1973 when a cattle feed supplement was switched with a toxic flame retardant in St. Louis, Michigan. The mistake was not discovered until a year later, after 70% of Michigan residents had been exposed to chemical contamination through their milk, eggs, and meat (Emory University 2015). The result of this chemical poisoning of polybrominated biphenyl (PBB) has impacted 9 million Michigan residents. Taxpayers have been funding the site cleanup, which is still not totally complete (Ellison 2016). As of 2017, decades after the original contamination, thyroid disease is common among men and women who were exposed (Jacobson et al. 2017). The health, ecological, and economic impacts are still experienced in and around St. Louis today (Ellison 2016).

In 2016, researchers from the University of Michigan's School of Public Health partnered with community leaders on issues related to environmental justice to analyze the distribution of environmental exposures, health risks, and social vulnerabilities in the Detroit metropolitan area. The team spatially and statistically analyzed the location of sensitive populations in terms of their proximities to hazardous land uses, exposure to air pollution, health risks, social vulnerabilities, and cumulative risk. Results showed that census tracts with greater proportions of people of color are disproportionately exposed to environmental harm,

socioeconomic vulnerability, and cumulative risk (Schulz, Mentz, Sampson, Ward, Anderson, de Majo, and Wilkins 2016).

In the wake of the Flint Water Crisis, Governor Snyder convened an Environmental Justice Work Group in February 2017 to provide recommendations to improve the environmental justice engagement of the government and its agencies (Environmental Justice Work Group 2018). The second recommendation in the work group's final report was for the State to "Develop an environmental justice screening tool in Michigan and include cumulative impacts in decision-making processes" (Environmental Justice Work Group 2018, 6). This recommendation reflects the need to assess the state of environmental justice as the State seeks to repair damage from the Flint Water Crisis, and as the MEJC seeks to establish a baseline of environmental justice in the state.

2.4 Spatial Analysis Tools: EJScreen, CalEnviroScreen, and Minnesota's Tools

Spatial analysis of locations of environmental hazards in relation to populations living nearby is an important aspect of assessing the existence and prevalence of environmental injustice. The US and many individual states have different approaches to spatial analysis of environmental justice. The US EPA's EJScreen tool (<https://ejscreen.epa.gov/mapper/>) is currently publicly available to environmental justice advocates and the general public all over the country (Kuruppuarachchi 2017). Aside from this national-level tool, two US states examined in this report that have varying approaches to spatial analysis include California and Minnesota. The California EPA (CalEPA) created CalEnviroScreen (<https://oehha.ca.gov/calenviroscreen>) with state-specific data (Kuruppuarachchi 2017). In addition, residents of Minnesota have access to several screening tools sponsored by the state's environmental quality agency, the Minnesota Pollution Control Agency (MPCA): What's in My Neighborhood (<https://pca-gis02.pca.state.mn.us/wimn2/index.html>) and Story Map (<http://mpca.maps.arcgis.com/apps/MapSeries/index.html?appid=f5bf57c8dac24404b7f8ef1717f57d00>)

(MPCA 2018). These tools provide helpful frameworks for considering a Michigan statewide spatial analysis tool in order to assess the state of environmental justice.

A. US EPA's EJ Screen

The EJScreen is a national environmental justice screening and mapping tool developed by the US EPA. The US EPA began developing this tool in 2010, had it peer reviewed in 2014, released it to the public in 2015, and updated its data in 2016 (Kuruppuarachchi 2017). The US EPA developed EJScreen in part to fulfill President Clinton's 1994 Executive Order requiring federal agencies to consider environmental justice implications of their actions (Environmental and Energy Study Institute 2016). EJScreen also supports EJ2020, the US EPA's national environmental justice strategic plan to be completed by the year 2020 (US EPA 2016).

The main focus of EJScreen is to map potential risk areas based on environmental and demographic indicators of a user-specified site (Kuruppuarachchi 2017). While this tool doesn't identify environmental justice communities, the US EPA does use it to discern communities that might need more support in terms of residents' public health and surrounding environment (EPAGroups 2016). EJScreen is also used to support US EPA's educational programs, grant distribution, and community awareness efforts, as well as to help the agency make sure its decisions uphold environmental justice (US EPA 2018a; Environmental and Energy Study Institute 2016). This tool is available to the public including citizens, agencies, and organizations (US EPA 2018a).

EJScreen employs data from the American Communities Survey at the census block group-level to examine social determinants of community members' health (Environmental and Energy Study Institute 2016). Demographic indicators displayed for each block group in the tool include:

- Percent Low-Income: "the percent of a block group's population in households where the household income is less than or equal to twice the 'federal poverty level'"

- Percent Minority: “the percent of individuals in a block group who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino”
- Less than high school education: “percent of people age 25 or older in a block group whose education is short of a high school diploma”
- Linguistic isolation: “percent of people in a block group living in linguistically isolated households (a household in which all members age 14 years and over speak a non-English language and also speak English less than ‘very well’)”
- Individuals under age 5: “percent of people in a block group under the age of 5”
- Individuals over age 64: “percent of people in a block group over the age of 64” (US EPA 2017a)

EJScreen calculates a “Demographic Index” of each census block group. To calculate a “Demographic Index,” only two of the six social indicators listed above are used: percent minority and percent low-income. The “Demographic Index” equals $(\% \text{ minority} + \% \text{ low-income})/2$. The tool also displays the following eleven environmental indicators for each census block group:

- National-Scale Air Toxics Assessment (NATA) air toxics cancer risk: “lifetime cancer risk from inhalation of air toxics”
- NATA respiratory hazard index: “air toxics respiratory hazard index (ratio of exposure concentration to health-based reference concentration)”
- NATA diesel particulate matter: “diesel particulate matter level in air”
- Particulate matter (PM_{2.5}): “PM_{2.5} levels in the air”
- Ozone: “ozone seasonal average of daily maximum 8-hour concentration in air”
- Lead paint indicator: “percent of housing units built pre-1960, as indicator of potential lead paint exposure”

- Traffic proximity and volume: “count of vehicles at major roads within 500 meters, divided by distance in meters”
- Proximity to Risk Management Plan (RMP) sites: “count of RMP facilities within 5 km (or nearest one beyond 5km), each divided by distance in kilometers”
- Proximity to Hazardous Waste Facilities: “count of hazardous waste facilities (TSDFs and LQGs) within 5km (or nearest beyond 5km), each divided by distance in kilometers”
- Proximity to National Priorities List (NPL) sites: “count of proposed and listed NPL - also known as superfund - sites within 5km (or nearest one beyond 5km), each divided by distance in kilometers”
- Wastewater Dischargers Indicator (Stream Proximity and Toxic Concentration): “RSEI modeled Toxic Concentrations at stream segments within 500 meters, divided by distance in kilometers (km)” (US EPA 2017a)

The tool combines the demographic and environmental information in an “Environmental Justice Index” (EJ Index), which signifies a community’s overall social and environmental vulnerability (EPAGroups 2016). “EJ Indexes” are calculated individually for each environmental indicator for each block group. The “EJ Index” of each block group is the calculated product of the environmental indicator, the “Demographic Index” for the block group minus the “Demographic Index” for the US, and the population count for each block group (US EPA 2017a).

The output of EJScreen includes both a map and report depicting the environmental indicators, demographic indicators, and “EJ Indexes” for each block group in user-selected communities of analysis. The map outputs are color coded for ease of interpretation, and resulting tables showing environmental indicators, demographic indicators, and “Environmental Justice Indexes” allow comparisons to average scores across the state, region, and country (Kuruppuarachchi 2017).

There are several main strengths and limitations of EJScreen. The output of the tool provides a detailed map and report that can be used for analysis of almost any area in the United States. Results allow users to compare different communities based on several screening indices. Further, users can add connecting technology, add their own data, and download the data used in the tool. However, the US EPA maintains that this tool should not be used for decision-making or to identify the location of environmental justice communities. Instead, it is limited to highlighting places that might be in need of further review. Additionally, while the tool is publicly available, it is only available in English, limiting who can actually use it. Finally, EJScreen does not provide information on actual exposure that communities experience, it only provides information on residents' potential for exposure (Kuruppuarachchi 2017).

The following images show the results and outputs of EJScreen when used to examine the location of the Stringfellow Acid Pits in Jurupa Valley, California. Note that while presenting a Michigan example would be ideal, a site in California was chosen to facilitate the side-by-side comparison of EJScreen and CalEnviroScreen results. As CalEnviroScreen only shows census tracts in the state of California, a site from that state is examined.



Figure 2. The national scope of data presented by EJScreen. Census block groups are color-coded based on “Environmental Justice Index” scores.

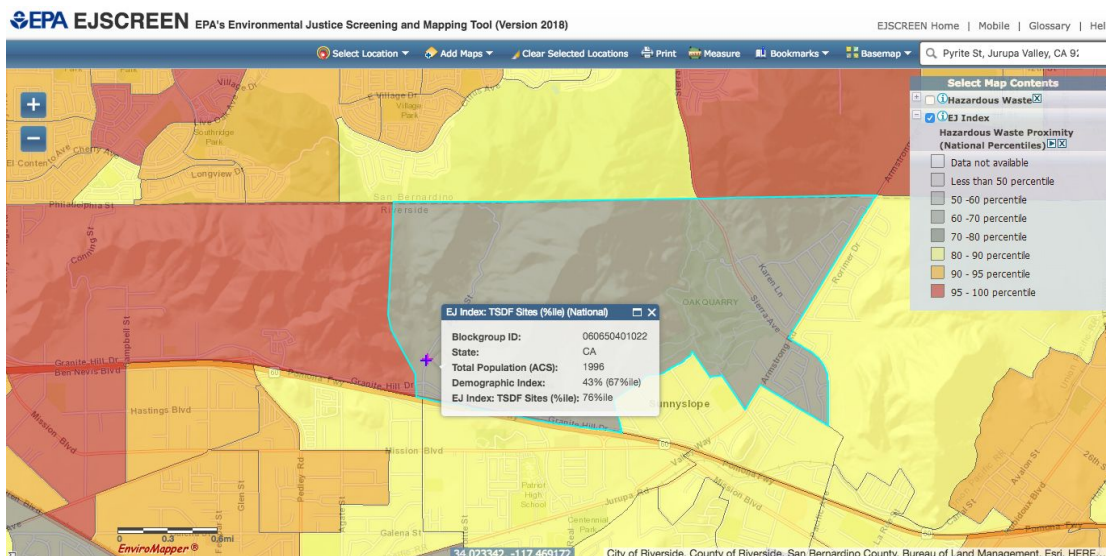


Figure 3. The census block (outlined in light blue) that hosts the Stringfellow Acid Pits in Jurupa Valley, California (designated with a blue “+”). Census block groups are color-coded based on “Environmental Justice Index” scores of Proximity to Hazardous Waste Facilities.



Figure 4. The report generated by EJScreen comparing the “Environmental Justice Indexes” for the area within three miles of the Stringfellow Acid Pits in Jurupa Valley, California to state, regional, and national scores.

These three figures show the outputs users can generate using EJScreen, the scope and scale of analysis possible, and the presentation of data both as maps and as graphs. Figure 2 demonstrates the national scope of the EJScreen tool for conducting spatial analysis, as it has social and environmental data on every state in the US. Figure 3 demonstrates that the census block that hosts the Stringfellow Acid Pits is in the 70-80th percentile in the country in terms of potential exposure of vulnerable communities to hazardous waste. Figure 4 compares the “Environmental Justice Index” scores of the block containing the acid pits to scores across the state, region, and country, and demonstrates that the block is relatively high in terms of disproportionate superfund proximity, hazardous waste proximity, and wastewater discharge indicators for the state, region, and country. These outputs from EJScreen demonstrate a potential vulnerability of the community that hosts the toxic waste in Jurupa Valley. These data could be helpful in analyzing the case of the dumping as a potential instance of environmental injustice.

B. CalEPA’s CalEnviroScreen

While EJScreen allows for the analysis of any state or region in the US, CalEnviroScreen provides more localized analysis of California. CalEnviroScreen is an environmental health screening tool used in the state of California that was developed by the California Environmental Protection Agency (CalEPA) and the California Office of Environmental Health Hazard Assessment (OEHHA) (Kuruppuarachchi 2017). CalEnviroScreen is the largest statewide public screening tool in the United States both in terms of geographic scope and the level of detail provided by the data. The tool originated from a 2010 CalEPA report describing the need for underlying science and general methods for identifying communities that face multiple sources of pollution in the state. The development process of CalEnviroScreen was transparent and involved public input, as the first draft of the tool was released in 2012 for public review and comment. Following twelve public workshops and over 1,000 comments, the first version of this tool was released to the public in 2013. A second version of the tool using updated data was released in 2014, and a third version, the current iteration, was released in January 2017. The

latest version includes two new measures capturing cardiovascular disease and the effects of high housing costs on low-income households (Faust et al. 2017).

CalEnviroScreen was developed, in part, to fulfill CalEPA's 2004 Environmental Justice Action Plan, which called for the development of guidance to analyze the impacts of multiple pollution sources on communities throughout the state. It is currently being used to direct state and local resources to revitalization efforts in disadvantaged communities, and to conduct statewide evaluations of environmental impacts on vulnerable communities. One of the most notable uses of the tool to date has been to inform CalEPA's identification of "disadvantaged communities," as mandated by the Senate Bill 535, which was passed into law in 2012 and requires at least 25% of funds earned from the state's cap-and-trade program to be invested in "disadvantaged communities" (Faust et al. 2017; CalEPA 2017). The tool is also used to inform AB 1550, which was passed into law in 2016 and requires at least 25% of funds from the Greenhouse Gas Reduction Fund to be invested in "disadvantaged communities" (OEHHA 2017). To designate "disadvantaged communities" in terms of environmental justice, CalEPA determines the highest scoring 25% of census tracts in the state on CalEnviroScreen, as well as 22 additional census tracts that score in the highest 5% of the "Pollution Burden" calculation but do not have an overall CalEnviroScreen score due to unavailable socioeconomic or health data (OEHHA 2017).

CalEnviroScreen displays data at the census tract scale and provides a score for each tract that is calculated by multiplying a "Pollution Burden" score with a "Population Characteristics" score (Faust et al. 2017). "Pollution Burden" indicators are divided into two categories: "Exposure" and "Environmental Effects." The first category, "Exposures" includes data on the following indicators:

- Ozone Concentrations: "mean of summer months (May-October) of the daily maximum 8-hour ozone concentration (ppm), averaged over three years (2012 to 2014)"
- Particulate Matter 2.5 Concentrations: "annual mean concentration of PM_{2.5} (average of quarterly means, micrograms/cubed meter), over three years (2012 to 2014)"

- Diesel Particulate Matter Emissions: “spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2012 summer day in July (kg/day)”
- Drinking Water Contaminants: “drinking water contaminant index for selected contaminants”
- Pesticide Use: “total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile, averaged over three years (2012 to 2014)”
- Toxic Releases from Facilities: “toxicity-weighted concentrations of modeled chemical releases to air from facility emissions and off-site incineration (averaged over 2011 to 2013)”
- Traffic Density: “sum of traffic volumes adjusted by road segment length (vehicle-kilometers per hour) divided by total road length (kilometers) within 150 meters on the census tract boundary (2013)” (Faust et al. 2017)

The second category, “Environmental Effects” includes data on the following indicators:

- Cleanup Sites: “sum of weighted sites within each census tract (data downloaded December 2016)”
- Groundwater Threats: “sum of weighted scores for sites within each census tract (data downloaded December 2016)”
- Hazardous Waste Generators and Facilities: “sum of weighted permitted hazardous facilities and hazardous waste generators within each census tract (permitted hazardous waste facilities was downloaded December 2016, hazardous waste data is from 2012-2014)”
- Impaired Water Bodies: “summed number of pollutants across all water bodies designated as impaired within the area (2012)”
- Solid Waste Sites and Facilities: “sum of weighted solid waste sites and facilities (as of December 2016)” (Faust et al. 2017)

The tool calculates a “Pollution Burden” score for each tract based on the average percentiles of the seven “Exposure” indicators and the five “Environmental Effects” indicators. “Environmental Effects”

indicators are given half the weight of the “Exposure” indicators. The average “Pollution Burden” score is divided by ten and rounded one decimal place. Final “Pollution Burden” scores range from 0.1 to 10 (Faust et al. 2017). This equation is displayed below.

$$[(\text{Avg \% for Exposure Indicators}) + (0.5 \times \text{Avg \% for Environmental Effects Indicators})] / (1 + 0.5)$$

“Population Characteristics” indicators are also divided into two categories: “Sensitive Populations” indicators and “Socioeconomic Factors.” The first category, “Sensitive Populations” includes data on the following indicators:

- Asthma Emergency Department Visits: “spatially modeled, age-adjusted rate of emergency department (ED) visits for asthma per 10,000 (averaged over 2011-2013)”
- Cardiovascular Disease (Emergency Department visits for Heart Attacks): “spatially modeled, age-adjusted rate of emergency department (ED) visits for AMI per 10,000 (averaged over 2011-2013)”
- Low Birth Weight Infants: “percent low birth weight (averaged over 2006-2012)” (Faust et al. 2017)

The second category included in “Population Characteristics” is “Socioeconomic Factors” and includes data on the following indicators:

- Educational Attainment: “percent of the population over age 25 with less than a high school education (5-year estimate, 2011-2015)”
- Housing Burdened Low Income Households: “percent of households in a census tract that are both low income (making less than 80% of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50% of their income to housing costs) (5-year estimates, 2009-2013)”
- Linguistic Isolation: “percent limited English-speaking households (2011-2015)”

- Poverty: “percent of the population living below two times the federal poverty level (5-year estimate, 2011-2015)”
- Unemployment: “percent of the population over the age of 16 that is unemployed and eligible for the labor force, excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2011-2015)” (Faust et al. 2017)

The tool calculates a “Population Characteristics” score for each census tract by averaging the percentiles for the “Sensitive Populations” indicators and the “Socioeconomic Factors” indicators. The calculated average percentile is divided by 10. Final “Population Characteristics” scores range from 0.1 to 10 (Faust et al. 2017). This equation is displayed below:

$$(\text{Avg \% for Sensitive Population Indicators} + \text{Avg \% for Socioeconomic Factor Indicators}) / 2$$

The “Pollution Burden” score and the “Population Characteristics” score are both scaled by the statewide maximum scores. To scale the “Pollution Burden” score, the calculated “Pollution Burden” percentile for each tract is divided by the highest “Pollution Burden” score for any tract in the state, then multiplied by ten. To scale the “Population Characteristics” score, the calculated “Population Characteristics” percentile for each tract is divided by the highest “Population Characteristics” score for any tract in the state, then multiplied by ten. A final CalEnviroScreen Score is calculated for each census tract by multiplying the “Pollution Burden” score by the “Population Characteristics” score of each tract (Faust et al. 2017). The maximum score for each tract presented in CalEnviroScreen is 100 (Kuruppuarachchi 2017). After each tract’s “Pollution Burden” score is combined with its “Population Characteristic” score, geographic areas are ordered from highest to lowest

based on overall scores (Faust et al. 2017). See [Appendix A](#) for a map displaying the final statewide results, as calculated and displayed on CalEnviroScreen (Faust et al. 2017).

Outputs of CalEnviroScreen include a map and a report of indicator scores of each tract. For ease of interpretation, maps are color coded based on overall scores: census tracts with darker red colors have higher scores, indicating higher pollution burdens and population vulnerabilities than census tracts with yellow to green colors. Outputs also include issue profiles, community comparison tables, and links to additional information about environmental justice issues to which communities are exposed (Kuruppuarachchi 2017).

There are several strengths and weaknesses to the CalEnviroScreen tool. This tool provides users with maps and reports on most census tracts in the state and allows users to compare exposure potential and vulnerability of different census tracts. Further, it puts health and environmental data in a usable form for the public. Users can add connecting technology and have the ability to download the data (Kuruppuarachchi 2017). The tool is also available for use in Spanish, making it more easily accessible by native Spanish speakers in the state and nation (OEHHA n.d.). However, this spatial analysis tool is limited by the fact that users are not able to add their own data, and by data gaps that exist in certain census tracts in the state (Kuruppuarachchi 2017).

The following images show the output and results of spatial analysis in CalEnviroScreen of the Stringfellow Acid Pits in Jurupa Valley, California.

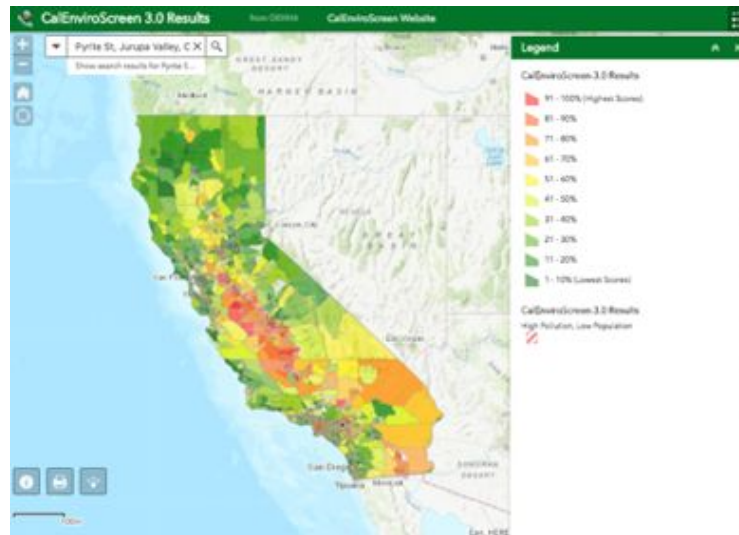


Figure 5. Display of statewide CalEnviroScreen scores, which combine the “Pollution Burden” and “Population Characteristics” scores for each census tract in the state. Scores are color coded based on vulnerability of census tracts.

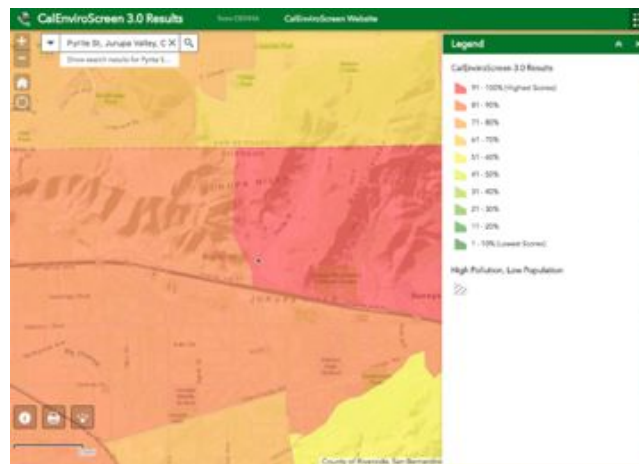


Figure 6. The census tract containing the Stringfellow Acid Pits in Jurupa Valley, California (designated with a blue circle). Based on this display, the reader can identify that the CalEnviroScreen score for this tract is in the 91-100 percentile for the state.

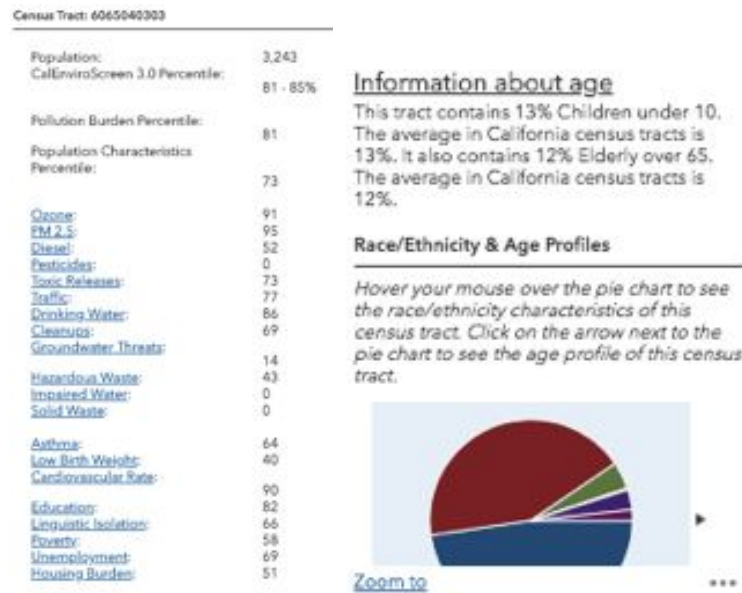


Figure 7 (left). The report generated by CalEnviroScreen depicting each “Pollution Burden” indicator score and Population Characteristics” indicator score for the census tract containing the Stringfellow Acid Pits.

Figure 8 (right). The report generated by CalEnviroScreen depicting age and the breakdown of the race/ethnicity of the census tract containing the Stringfellow Acid Pits.

Figure 5 depicts the state-wide scope of the spatial analysis capabilities of CalEnviroScreen. Results are color coded based on each tract’s CalEnviroScreen score. Figure 6 demonstrates that the census tract containing the Stringfellow Acid Pits is in the 91-100 percentile in the state in terms of its CalEnviroScreen score. Figure 7 reports that the tract containing the acid pits is currently home to over 3,000 residents, is especially susceptible to exposure to ozone and PM2.5, and is vulnerable in terms of cardiovascular disease, education, and linguistic isolation. Figure 8 reports that the vast majority of the population in this tract is either white or Hispanic. Outputs from CalEnviroScreen can be used to determine if the dumping of toxic waste in Jurupa Valley has made the community disproportionately more vulnerable in terms of exposure to environmental hazards.

Analyzing the case of the Stringfellow Acid Pits in Jurupa Valley, California demonstrates several of the strengths and limitations of both EJScreen and CalEnviroScreen and allows a comparison of both tools. Both tools present information to users in the form of color coded maps, along with reports with information on

specific geographic regions. Color coding makes these map outputs user-friendly and accessible for analysis, while the tables and reports facilitate the comparison of areas across the state and country. Both tools combine social and environmental indicators and compare similar data categories including data on environmental hazards and on population vulnerability (Kuruppuarachchi 2017).

There are five major differences between EJScreen and CalEnviroScreen. First, the tools operate at different scales. While EJScreen allows spatial analysis of any state or region in the country and permits users to compare justice concerns across different states, CalEnviroScreen allows environmental justice analysis only in California (Kuruppuarachchi 2017).

Second, the data used in CalEnviroScreen is more detailed than the data used in EJScreen, permitting users to conduct a more thorough analysis of environmental justice concerns. Pollution data that users can analyze in CalEnviroScreen that they cannot using EJScreen include pesticide exposure, and drinking water versus wastewater threats versus impaired water, as opposed to the single water category presented in EJScreen. Social and health characteristics that users can analyze in CalEnviroScreen that they cannot using EJScreen include potential for contracting asthma, low birth weight of infants, unemployment, and housing burden (Kuruppuarachchi 2017). An objective of this project is to determine how much of these kinds of data are available in the state of Michigan through a data gap analysis.

Third, EJScreen allows spatial analysis at the census block level, while CalEnviroScreen allows analysis at the census tract level (Environmental and Energy Study Institute 2016; Faust et al. 2017). It is important to conduct spatial analysis at a level as small as the census tract or block group level, as environmental justice is such a localized issue that can vary at levels as small as neighborhoods (Environmental and Energy Study Institute 2016).

Fourth, the US EPA does not use EJScreen to identify environmental justice communities, while the CalEPA uses CalEnviroScreen to identify “disadvantaged communities” (Environmental and Energy Study Institute 2016; CalEPA 2019). The guidelines used by CalEPA to determine disadvantaged communities can be

applied to other areas in the country. However, this difference in willingness to use spatial analysis tools to identify communities where environmental justice issues are occurring means that EJScreen use and results do not directly have policy impacts and implications, while CalEnviroScreen use and results do.

Fifth, CalEnviroScreen provides a ranking of census tracts in the state based on cumulative impacts, as reflected in CalEnviroScreen scores. CalEnviroScreen displays this ranking through the color coding of tracts. On the other hand, EJScreen does not provide a ranking of areas at any geographic scale. EJScreen calculates “EJ Indexes” separately for each environmental indicator instead of based on potential cumulative exposure.

C. Minnesota’s Tools

A third set of relevant environmental justice screening tools comes from the State of Minnesota, where government resources have been allocated to create two web-based tools for visualizing the spatial patterns of environmental justice communities in Minnesota. These tools have been created by, or with support of, the Minnesota Pollution Control Agency (MPCA). Similar to the Michigan Department of Environmental Quality, the MPCA enforces environmental regulations and issues permits to industrial sources of pollution. However, MPCA does not regulate drinking water systems like MDEQ or CalEPA. Also unlike California and Michigan, Minnesota has several state departments and agencies that address issues related to environmental quality instead of just one. These departments and agencies include MPCA as well as the Department of Health’s Environmental Health Division (MPCA 2015).

Minnesota has created two separate screening tools that both use various datasets to identify “areas of environmental justice concern.” The first is an interactive Story Map that shows “areas of environmental justice concern” in the state, using census tract boundaries to define areas. The second tool is the What’s in My Neighborhood web-based mapping and text-based search tool that also displays data at the census tract level. These two screening tools were formally created and hosted by the state government.

The ‘Story Map’ tool uses ESRI’s ArcGIS Online platform to show the “areas of environmental justice concern” within the state of Minnesota so that users can identify census tracts that might warrant additional attention in terms of environmental justice. Areas of concern in Minnesota are defined as either having “at least 40% of people reported income less than 185% of the federal poverty level,” “50% or more people of color,” or “federally recognized tribal areas” (MPCA n.d.) The tool displays data on the following indicators as separate layers:

- People in poverty: census tracts where “at least 40% of people reported income less than 185% of the federal poverty level”
- People of color: census tracts where “at least 50% of the people identify as people of color”
- Tribal areas: “federally recognized US Census Bureau’s tribal areas”
- Language: allows users to “zoom in to a specific area identified as an ‘area of concern for environmental justice’ and see the top three languages spoken by non-English speakers” (MPCA n.d.)

The What’s in My Neighborhood tool provides information on various sites of environmental interest, including feedlots and solid waste facilities. In addition to facility data, there is data on air and water quality, and information relevant to permits. This tool does not provide any analysis of socio-economic or health data surrounding the sites of environmental interest (MPCA n.d.).

Though there is no technical document with detailed information on the datasets, this tool displays data relevant to the following indicators:

- Air quality
- Environmental review
- Feedlots
- Hazardous waste
- Investigation and cleanup

- Pollution prevention
- Solid waste
- Subsurface sewage treatment systems (SSTS)
- Stormwater
- Tanks
- Water quality (MPCA n.d.)

Considering Minnesota's use of environmental justice screening tools alongside that of the US EPA and CalEPA is helpful as Minnesota is also a Great Lakes state with a size similar to that of Michigan.

2.5 Environmental Justice According to US EPA, California, Minnesota, and Michigan

The US EPA, CalEPA, MCPA, and MDEQ all define and conceptualize environmental justice differently. All agencies define environmental justice as a concept, while several agencies also define criteria for identifying environmental justice areas and/or communities.

According to the US EPA, "environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." The US EPA does not currently define environmental justice areas and/or communities (US EPA 2019).

California both defines environmental justice and employs criteria for identifying "disadvantaged communities." California defines environmental justice in its government code § 65040.12 (2013) as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies." CalEPA defines "disadvantaged communities" in the introduction of the *Designation of Disadvantaged Communities Pursuant to Senate Bill 535*. The definition states, "CalEPA is designating the highest scoring 25% of census tracts from

CalEnviroScreen 3.0 as disadvantaged communities. Additionally, 22 census tracts that score in the highest 5% of CalEnviroScreen's Pollution Burden, but do not have an overall CalEnviroScreen score because of unreliable socioeconomic or health data, are also designated as disadvantaged communities" (CalEPA 2017).

The Minnesota Pollution Control Agency also defines environmental justice as a concept and provides criteria for identifying areas of concern. MPCA defines environmental justice in its *Environmental Justice Framework Report* as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." Further, "the Agency considers a census tract to be an area of concern for environmental justice if it meets one or both of these demographic criteria: the number of people of color is greater than 50%; or more than 40% of the households have a household income of less than 185% of the federal poverty level." Additionally, the MPCA considers communities within Tribal boundaries as "areas of environmental justice concern" (MPCA 2018).

Finally, the State of Michigan defines environmental justice as a concept. According to *Executive Directive No. 2007-23* signed by Governor Granholm in 2007, environmental justice is defined as "the fair, non-discriminatory treatment and meaningful involvement of Michigan residents regarding the development, implementation, and enforcement of environmental laws, regulations, and policies by this state" (Granholm 2007). The State of Michigan does not currently provide criteria for identifying communities vulnerable to environmental injustice.

This information on history, definitions, methods, and perspectives on environmental justice provides a framework for this research and project. The next chapter of the report discusses the methodologies used in the qualitative analysis of this study, which involved completing and analyzing interviews with thirty environmental justice leaders in the state.

Chapter 3. Qualitative Analysis Methodology

This chapter describes the methodologies the research team used for qualitative data collection and analysis. As mentioned in the introduction, the qualitative portion of this study relies on information gathered from a diverse group of actors involved in environmental justice in Michigan including scholars, professionals, and community activists. For the purpose of brevity, the authors address this diverse group of interviewees as “environmental justice leaders” throughout this document.

3.1 Qualitative Research Questions

The qualitative portion of this project sought to answer the following research questions:

- What is the state of environmental justice in Michigan?
- What are the salient environmental risks and impacts environmental justice leaders in Michigan know about, perceive, and experience?
- How do environmental justice leaders view and use data and assessment tools?

3.2 Sampling Strategy

To address these specific questions, the research team interviewed thirty environmental justice leaders in the state of Michigan. The researchers employed a convenience sampling technique utilizing contacts provided by the MEJC, as well as a snowball sampling technique. Both processes are explained below. Interviewees fell into three different interview samples.

The first sample consisted of MEJC members. The MEJC provided a list of its membership at the start of the outreach process. The research team reached out to all 22 contacts on the list via email. When members

responded, interviews were scheduled. When a week passed with no response, the team followed up via email a total of three times for each MEJC member. The research team interviewed 12 members of the MEJC (n=12).

The second interview sample consisted of snowball contacts collected from the MEJC members interviewed by the research team. The final question asked of each interviewee was if they could recommend another environmental justice leader in the state of Michigan. MEJC interviewees provided 17 new contacts. The team reached out to all 17 contacts via email and interviewed eight (n=8).

The third interview sample consisted of individuals who submitted a proposal to present at the MEJC's statewide Environmental Justice Summit that occurred in Flint, Michigan in September 2018. This sample was added to the outreach process in an effort to capture greater geographic diversity across the state of Michigan. The MEJC provided a list of names and contact information of these individuals who submitted proposals. The team reached out to all 26 applicants via email and interviewed ten of them (n=10). See Table 1 below for a summary table of interview samples and sizes.

Interview Sample	Number of People Contacted	Size of Sample (N)	Response rate
MEJC Members	22	12	55%
Snowball Contacts	17	8	47%
Summit Presentation Applicants	26	10	38%
Total	65	30	46%

Table 1. Size of interview samples.

3.3 Design and Implementation of In-Depth Interviews

To answer the research questions delineated in this section, the team developed a semi-structured interview guide to elicit the knowledge, perspectives, and experiences of Michigan environmental justice leaders (see [Appendix B](#)). The guide consisted of two sets of interview questions: one for leaders who self-identified as

currently residing or working in areas affected by environmental justice issues and the other one for professionals, scholars, and activists who are not currently affected by environmental injustice but work with, advocate for, study with, or represent these communities in some capacity.

Both sets of questions underwent multiple reviews. First, the interview guide was reviewed by the project advisor, Dr. Paul Mohai, as well as other faculty at SEAS. Second, the researchers incorporated feedback from the MEJC. Lastly, the researchers conducted three pilot interviews with emerging leaders in Michigan with relevant experience working alongside MEJC. Feedback from the three pilot interviews was integrated, and some questions were clarified to ensure comprehension.

Once the interview guide was finalized, interviews were scheduled with respondents either in person, when possible, or over the telephone. If interviewing in person, the respondents were offered to conduct the interview at the University of Michigan Detroit Center, the University of Michigan Dana Building in Ann Arbor, or a location of their choice. If conducting the interview over the phone, a conference call number was provided.

All participants were provided with detailed information about the study and privacy considerations. The research team obtained informed consent from all participants through a process approved by the University of Michigan's Institutional Review Board (IRB). The outreach methods and examples of email outreach scripts were also approved by the IRB. The researchers strived to maintain high standards of ethical conduct throughout the design and implementation of the interviews.

The interview guide was divided into three parts and was designed to last from thirty minutes to an hour. First, the respondents were asked about their involvement in environmental justice. Second, questions were asked to assess strengths of environmental justice communities, available resources, as well as recent advances for environmental justice in the state. Participants were also asked about salient risks and impacts associated with environmental issues, and how these affect the day to day lives of affected community members.

Finally, a set of questions was asked regarding assessment tools and processes used to gather and disseminate information about risks and impacts.

The interviews were recorded on the interviewer's password-protected phone after obtaining consent from each participant. These recordings were then transcribed and saved in a password protected private university account within 72 hours of the interview. The recordings were subsequently deleted from the phone. A subset of the interviews were transcribed by the transcription service Rev.com following the same timeline. At the conclusion of the interview, participants were provided with a small gift symbolizing the gratitude of the researchers for their participation. In accordance with IRB guidelines, this gift was not utilized as a recruitment tool, as the participants had not been informed about it before scheduling the interview. Immediately following each interview, the interviewer wrote a memo capturing perceived salient themes, notes about the interaction, and preliminary interpretations of the interviewee's responses.

The interviews yielded rich information about the state of environmental justice in Michigan, as well as advances and challenges of advocacy for environmental justice issues and communities. Furthermore, leaders provided insights about how a Michigan-specific assessment tool could be of assistance to leaders in the study and advocacy of these issues.

3.4 Interview Data Analysis

The researchers adopted an inductive approach to qualitative data analysis drawing from Grounded Theory, which allows for the interpretation of data without having a predetermined hypothesis (Charmaz 2014). This approach was selected as this study was exploratory in nature and it was important to allow the participants to determine the salient concerns regarding environmental justice in the state of Michigan.

The first analytical step was to develop a codebook by identifying patterns in the data and organizing these patterns into themes and subthemes. An initial codebook was developed based on the interview questions with two sections, one devoted to information about the state of environmental justice in Michigan, and the

second section devoted to responses about informational tools. Each of the three samples (MEJC members, summit applicants, and snowball respondents) had a separate codebook and their responses were coded separately. Responses from the three separate codebooks were then compared in order to identify differing patterns across the three groups. Differences across these three codebooks were minor; therefore, all codebooks were then combined into one final codebook that reflected themes and subthemes that were consistent across samples. The results and trends gleaned from this codebook, as well as the minor differences found across codebooks, are discussed in [Chapter 4.2 Prominent Interview Themes](#).

The research team coded each of the thirty interviews manually. For each of the thirty interviews, team members highlighted information relevant to the research questions and labeled it with short descriptive phrases (codes), as described by the authors of the *Fundamentals of Qualitative Data Analysis textbook* (Miles et al. 2014). After coding each interview, the team reviewed the accompanying memo written by the interviewer at the time of the interview to ensure the inclusion of relevant information. Codes were added to the three different codebooks according to which sampling frame the interviewee was from. Themes, subthemes, and codes were then compared across codebooks. A minority of codes and subthemes that captured differences across samples were noted and are discussed in [Chapter 4](#). Themes, subthemes and codes that were consistent across all three codebooks were combined into one comprehensive codebook to capture data from all three samples. While the codebook is kept confidential, the results are displayed in the following chapter. The next step in qualitative data analysis was to create matrices displaying the overall patterns for notable themes and subthemes based on code frequencies.

The final step in the interview data analysis was analyzing the word frequency from interview transcripts. Because major differences across samples were not found during the first step of analysis described above, the team conducted the word frequency analysis for all thirty interviews as one combined sample. To complete this analysis, a word frequency chart was generated using NVivo, a qualitative data analysis software. This chart lists the 100 most used words in all interviews. With this information, a word cloud was created,

displaying the 100 most used words. Questions asked by the interviewer were removed from the transcripts to generate this chart and word cloud.

Chapter 4. Qualitative Analysis Results

This chapter presents results of qualitative data analysis. The results of qualitative data analysis take the form of a word cloud displaying the top 100 most frequently used words during interviews, and a discussion of prominent themes and subthemes conveyed during interviews including matrices displaying these themes and subthemes when helpful for data visualization.

4.1 Word Frequency Cloud

The team used NVivo, a qualitative data analysis program, to create a word cloud displaying the top 100 most frequently used stemmed words from the responses of the thirty interview transcripts. As mentioned in [Chapter 3](#), differences in the thematic analysis of the three samples were minimal, thus word frequency analysis was conducted for all interviews as one combined sample. Words only related to the interview process but not directly related to the research question “What is the state of environmental justice in Michigan?” were removed, such as the following words: inaudible, yes, got, and probably. The size of the words in the word cloud is proportional to the relative frequency with which they were used: words that appear larger in the word cloud were used more frequently than words that appear smaller. For a list of the top 100 words used in the thirty interviews, see [Appendix C](#). The resulting word cloud is displayed below in Figure 9.



Figure 9. Top 100 most frequently used words from interviews with thirty environmental justice leaders in Michigan.

4.2 Prominent Interview Themes and Subthemes

The interview coding process illuminated broad themes concerning the state of environmental justice in Michigan and leaders' use of tools. Each broader theme was further broken down into subthemes, which are listed below in Table 2.

Themes	Subthemes	
Community Assets	Recent Wins	
	Community Strengths	
	Resources	
Community Vulnerabilities	Risks and Impacts	Environmental Risks and Impacts
		Socioeconomic Risks and Impacts
		Health Risks and Impacts
	Forms of Environmental Injustice	Procedural Injustice
		Distributive Injustice
		Corrective Injustice
	Barriers to Advancing Environmental Justice	
Tools	Existing tools	
	EJScreen Use	
	Michigan Tool Recommendation	
	Reporting Mechanisms	

Table 2. Themes and subthemes of interview data.

Themes and subthemes were consistent across the three samples (MEJC members, summit applicants, and snowball contacts). The only difference found across samples was that summit applicants did not mention as many air quality risks and impacts as MEJC members and snowball contacts did, potentially because summit applicants were more representative of rural areas. This inconsistency could be indicative of the differences between rural and urban environmental concerns, where air quality concerns might be more relevant in urban areas, and all other concerns might be relevant to both rural and urban areas. A quote from an interview with an

environmental justice leader in Michigan spoke to the importance of addressing environmental justice in general:

“Well environmental justice encompasses, just, it’s intersectional. It’s just about every other issue that goes on. It has to do with the climate change. It has to do with water quality. It has to do with industrial agriculture. It has to do with how we exploit animals and human labor in the making of our food, growing it, distributing it, even at the restaurants. Environmental justice is about living wage. It’s about children’s brains not developing to their full capacity. It is about education and it’s not something that should be relegated to another topic on the agenda. It is the agenda. And if we don’t deal with the whole environment as a whole and adjust this issue as well, we’re gonna be in pretty sad shape, if we don’t kind of reverse some of these things that we’re doing today.”

This quote acknowledges the significance of these data and research and sets the stage for the following presentation of the results of interview data analysis. Results are described in terms of broad themes and more specific subthemes.

Community Assets

The “community assets” theme describes advantages and benefits interviewees experience as a result of living in or working with communities affected by environmental injustice. This theme includes the subthemes “recent wins,” “strengths,” and “resources.”

Community Assets: Recent Wins

The first subtheme that comprises the “community assets” theme is “recent wins.” When asked about recent wins Michigan residents of communities impacted by environmental justice have experienced, the most common response was that communities have seen an increase in awareness about and engagement with environmental justice issues. According to participants, community members have been bridging divides between factions by creating coalitions across diverse groups with varying cultures, languages, racial and ethnic backgrounds, and issue priorities (water, food, and air). Participants also referred to community members

changing their engagement strategies and narratives as a recent win. Several participants spoke of increasing funding sources, in addition to Community Benefits Agreements.

Interviewees discussed recent wins involving government and industry, noting recent favorable decisions regarding permits, zoning changes, and other requests to expand industrial activities in areas impacted by environmental justice. Participants noted the newly formed positions of Environmental Justice and Tribal Liaison at the Michigan Department of Environmental Quality (MDEQ) and the Environmental Justice Ombudsman in the Governor's office as wins. Further, according to interview participants, the Michigan Department of Environmental Quality (MDEQ) has been changing its procedures to provide more space in public hearings and increase communication with community advocates. Several participants discussed local government officials who supported the community and have increasingly advocated for environmental justice through actions such as lawsuits. Finally, interviewees mentioned increased communication with the government as a recent win.

Community Assets: Strengths

The second subtheme that comprises the "community assets" theme is "strengths." When asked about strengths of communities that experience environmental injustice in Michigan, the most common responses described characteristics of community members. Interviewees described community members as resilient, creative, resourceful, and possessing strong cultural values and positive attitudes. One participant spoke to the creative nature of residents when they said, "*Creativity is one thing, not just what people call art, but I guess you could say social creativity, which involves creating different independent projects.*" Many participants also highlighted the strong connection to nature, high engagement in pro-environmental behaviors, and positive relationships among community members. Data also described communities impacted by environmental injustice as having strong grassroots movements with fruitful community meetings and effective community organizations. Collaboration between community organizations was mentioned as a community strength.

Finally, participants expressed a high attachment to place and pride in their communities, highlighting desirable physical attributes of their regions along with meaningful historical significance of their neighborhoods.

Community Assets: Resources

The third subtheme that comprises the “community assets” theme is “resources.” When asked about advocating for communities impacted by environmental injustice, the most commonly mentioned resource was community organizations, followed by pro-bono legal assistance and health clinics. Funding for these community organizations was also described as a resource. Government resources mentioned by interviewees included the involvement of the US EPA along with local and state representatives who support the advancement of environmental justice. Further, participants noted the importance of national organizations and movements that bring attention to environmental justice issues and may provide funding and tools. Several environmental justice leaders mentioned academic resources, including community-academia partnerships, published academic studies, community based participatory research, and spatial analysis tools developed by academics. Additionally, participants cited the law or legal processes, such as Community Benefits Agreements, as resources.

Communication tools were often mentioned by interviewees. These tools included social media, community telephone lists, and networking opportunities with other community members and organizations. Participants mentioned resources that directly aid residents including water filters, water stations, gardens, cooling centers, transportation, and translation services. Finally, environmental testing, monitoring, and remediation were included as resources.

Community Vulnerabilities

The “community vulnerabilities” theme describes sensitivities or challenges interviewees experience as a result of living in or working with communities affected by environmental injustice. This theme includes three categories of subthemes. The first category describes risks and impacts discussed by the interviewees and includes the subthemes “environmental impacts,” “socioeconomic risks and impacts,” and “health risks and

impacts.” The second category describes three different forms of environmental injustice and includes the subthemes “procedural injustice,” “distributive injustice,” and “corrective injustice.” The third and final subtheme describes “barriers to advancing environmental justice.”

Community Vulnerabilities: Environmental Risks and Impacts

While risks and impacts are broken down into three different subthemes, it should be noted that participants stressed the interrelatedness of environmental, socioeconomic, and health risks and impacts. In describing how these types of impacts are connected, one interviewee said, *“We get a lot of volunteers from more affluent communities who ask us ‘Well, why are you talking about this? That doesn’t have anything to do with environment.’ We have to explain to them why minimum wage or why issues around racial justice are also important because I think they are linked very intimately with what’s going on in the communities.”* A detailed list of codes for each of these subcategories of risks and impacts have been displayed in Tables 6, 7, and 8.

The first subtheme that comprises the category of risks and impacts in the “community vulnerabilities” theme is “environmental impacts.” Many interviewees spoke about the legacy of pollution resulting from manufacturing, highlighting the concentration of industry in low-income and minority areas. They described industry as encroaching on people and in residential areas, and mentioned that pollution is currently increasing in these areas. The environmental justice leaders often spoke of effects of pollution on surrounding water, air, land, and food. Some spoke in general terms while others listed specific facilities and specific toxins of interest. The most commonly mentioned impacts were decreased air and water quality. For example, in describing air quality issues one participant said, *“Our home is always, always getting dust from somewhere. We have to clean it. There’s always dust. Also, the smell in the neighborhood. Sometimes it gets really foul smell, especially around the school. When it rains, it really, really is so bad. On certain days it really is bad when it rains.”* In discussing water quality issues, another interviewee said, *“The mercury pollution affects our relationship with the fish that we can no longer eat indiscriminately. Pregnant women, some of them are advised that they should never eat fish. Others*

maybe once a month at the most. This has been a really big part of our culture.” Data analysis indicates that water issues impact different communities in varying ways.

Environmental Risks and Impacts				
Air	Water	Land and Food	Pollution Sources	Pollutants
Decreased air quality Rail traffic Vehicle traffic Truck routes Particulate matter Vapor intrusion (trichlorene, TCE) Dust Odors Poor indoor air quality	Lead in water Water runoff Groundwater quality Surface water quality Poor water quality Pharmaceuticals in water supply Climate change	Contaminated soil Changing landscape Less green space Lack of access to the outdoors Increasing impervious surfaces Heat waves Transport of toxic materials through residential areas Commercial fishing impacts on tribal fishing operations Food contamination Waste/garbage Noise pollution Vibrations Demolitions	Oil refineries Pipelines Power plants Hazardous waste facilities Landfills Wastewater treatment plants Superfund sites Military bases Mining operations Large agricultural operations CAFOs Incinerators Fracking/natural gas operations Steel mills Chemical plants Cement/asphalt plants Salt mines Dry cleaning Tanneries Coal based facilities	Sulfur dioxide Nitrogen oxide Neurotoxins Petroleum coke Coal ash Fire retardant/PBB PCBs DBTs DDE DDT PFAS Petroleum Mercury pollution Microplastics Lead Lead paint

Table 3. Environmental risks and impacts.

Community Vulnerabilities: Socioeconomic Risks and Impacts

The second subtheme that comprises the category of risks and impacts in the “community vulnerabilities” theme is “socioeconomic risks and impacts.” Participants stressed the significance of socioeconomic risks and impacts stating that these can create additional barriers that compound the inability of community members to deal with environmental impacts. For example, participants cited difficulty in accessing health care when experiencing health impacts resulting from environmental exposure. One interviewee referred to the intersection of economic risks and environmental impacts when they stated, *“People don’t have access to*

health care services. They don't have access to the financial wealth that they need to live a more healthy life. Having a clean environment is part of that as well." Another leader spoke to these connections when they said, *"Not only are they exposed to more pollution than they should be, and certainly more than the state average, they also have less access to health care."*

The most salient socioeconomic risks and impacts discussed were poverty, unemployment, and underemployment. Other economic impacts mentioned were missing work days as a result of illness, water shutoffs, and agricultural losses due to contamination. Many participants also referenced gentrification, housing insecurity, and living in areas with mixed residential and industrial zoning designations that place residents too close to polluting industries. Participants noted how the economic power of communities has changed throughout the years. For example, one interviewee said, *"This was a place in which everyday people could have a high standard of living. You didn't have to go to college. You could work and earn a living and buy a car and buy a house and raise your family and stuff like that. Now, you see all the people fighting all over the country for living wages and such. We don't have that anymore."*

Environmental justice leaders also spoke of impacts on children specifically and noted that schools are often located near industries. Children at these schools are exposed to industrial pollution and experience increased school absences due to respiratory illness and experience decreased educational attainment. Other socioeconomic impacts result from political processes such as disinvestment in neighborhoods and political disenfranchisement. Participants described neighborhoods that lack city services such as trash removal, recycling, and public transportation. Interviewees also cited a lack of resources provided to assist with relocation to neighborhoods where city services are available. They noted how, in addition to waste and lack of connection between residents in communities, crime and violence were common. The crime and violence they experienced in their neighborhoods often resulted in physiological and psychological health impacts. Finally, leaders discussed social impacts of racial discrimination, inability to participate in cultural practices, and destruction of archeological remains belonging to indigenous populations.

Socioeconomic Risks and Impacts				
Economic	Housing	Education	Political	Social
Poverty Un/under-employment Missing work days Lack of economic power of communities Agricultural losses Lack of healthcare access Lack of healthy food access Food insecurity Water shutoffs High water prices Damaged water lines and appliances Lack of access to free bottled water/clean water Privatization of water Energy poverty Lack of access to transportation Digital divide	Blight Housing insecurity Lowered housing values Gentrification Racial segregation Mixed residential and industrial zoning	Lower educational attainment Missing school days School-to-prison pipeline Inadequate transitions to college and adulthood	Political disenfranchisement Lack of city services Disinvestment	Racial discrimination Violence Crime High proportion of foreign language speakers Lack of archaeological evaluations of indigenous cultural artifacts Mining in sacred/historical grounds Impacts on cultural or religious practices

Table 4. Socioeconomic risks and impacts.

Community Vulnerabilities: Health Risks and Impacts

The third subtheme that comprises the category of risks and impacts in the “community vulnerabilities” theme is “health risks and impacts.” During interviews, participants provided detailed information about diseases and symptoms community members experience as a result of environmental exposure. The most cited health conditions included asthma and cancer. Cited less often were cardiovascular disease, diabetes, and endocrine disruption, among others. Some common symptoms interviewees mentioned included headaches, nausea, and breathing difficulties. According to participants, these conditions frequently result in high hospitalization rates, disability, and death. Multiple participants had suffered personal losses they attributed to growing up and living in areas affected by environmental injustice, and some of them disclosed

having survived cancer and other serious health conditions. For example, one interviewee described the prevalence of asthma among their peers when they said, *“I played a lot of sports in high school and there would always be somebody who had asthma, there would be three or four people who actually had medication and they would have the inhaler for the team. Things like that... I’m starting to make sense as to why.”*

A distinct subset of health risks and impacts were categorized as emotional or psychological in nature and are considered an emergent subtheme, as the research team did not anticipate gleaning this set of responses. According to several participants, emotional and psychological impacts receive insufficient attention and are often ignored by government officials. Interviewees described experiencing feelings of hopelessness, sadness, frustration, and fatigue on a regular basis as a result of perceived lack of environmental protection for vulnerable communities. They described trying to advance environmental justice for many years without witnessing many results and feeling like they were ignored by their elected officials. Additionally, many interviewees discussed the emotional ramifications of having gone through illnesses themselves or of having experienced the loss of property or loved ones. For example, one leader stated, *“I also think there is a fatigue and a sense of hopelessness on the part of a lot of people that are like ‘We fought these battles before. I’ve been to your public meetings. I’ve gone to your events and nothing changes... people feel like they are fighting an insurmountable battle.’”* This emergent theme highlights the impact of living through and witnessing environmental injustice on people’s mental health. All health risks and impact mentioned are listed below in Table 5.

Health Risks and Impacts			
Health Symptoms	Health Diseases and Disorders	Psychological Symptoms	Psychological Disorders
Breathing difficulties Headaches Immune system decline Muscle-skeletal effects Respiratory effects Eye irritation Nausea from fumes and odors	Developmental disorders Endocrine disruption Cancer Obesity Diabetes Asthma Respiratory illnesses Autoimmune disease Cardiovascular disease Death Disability Hospitalization Organ failure Hearing impairment	Increased stress Hopelessness Powerlessness Disheartenment Increased fear Fatigue Burnout Sadness Frustration Sense of urgency	Pediatric behavioral impacts of exposure to neurotoxins Post Traumatic Stress Disorder (PTSD)

Table 5. Health risks and impacts.

Community Vulnerabilities: Procedural Injustice

The first subtheme that comprises the category of forms of environmental injustice in the “community vulnerabilities” theme is “procedural injustice.” These responses refer to a lack of access to decision-making processes. The two most frequently cited issues were a lack of governmental transparency and a lack of information provided to communities by government and industry. Participants also commonly highlighted erosion of democratic processes, discussing the appointment of emergency managers whose decisions superceded those of democratically elected officials, the continued use of redistricting or gerrymandering by politicians to restrict the political power of vulnerable communities, and the passing of bills that create oversight mechanisms that limit the decision-making power of governmental agencies. For example, one participant addressed the erosion of democracy when they stated, *“One of the root causes of creating barriers towards achieving environmental justice is the lack of democracy. Flint Water Crisis is the perfect example of what happens with local communities. Their democracy is taken away from them. You’re seeing that happen through the standard*

administration for many years in terms of emergency management and how communities are... decision-making power is taken from them.”

Participants also frequently stated that communities are unable to participate in decision-making process and do not feel heard by the government. They expressed a lack of trust in governmental agencies. For example, one interviewee discussed feeling like their concerns with industry are not heard when they said, *“Community members sit down and try to talk and say these are the things that are actually happening, these are the things that need to be discussed, and none of their comments are taken into consideration. They [industries] just get a slap on the hand, no fines, and go on with their business.”*

Specific barriers to participation in decision-making include lack of time, lack of advertising of public comment periods, lack of adequate space in public hearings, lack of translation of documents, and lack of community representation on industry and governmental committees. Finally, some participants pointed out that certain populations are further excluded from decision-making. Native Americans are excluded based on lack of jurisdiction of historic indigenous lands, and immigrant populations, such as migrant farmers, are excluded based on lack of citizenship.

Community Vulnerabilities: Distributive Injustice

The second subtheme that comprises the category of forms of environmental injustice in the “community vulnerabilities” theme is “distributive injustice.” These responses refer to a disproportionate distribution of environmental benefits and harms. Participants stated that pollution is unequally distributed and that low-income and communities of color bear the burden of most pollution emitted in Michigan. One interviewee stated, *“All of these [impacts] are generally to people that didn’t cause the problems, but now are paying the price. That’s an environmental justice issue.”*

Examples of disproportionate distribution of environmental harms included presence of fracking in poor areas and the construction of an international bridge in a low-income and minority community. Further, participants discussed the disproportionate impact incinerators in Michigan have on low-income populations,

African Americans, and children who live in close proximity. Additionally, interviewees expressed that the communities most impacted by dependence on fossil fuels are the communities with the least amount of capital to address associated problems. Furthermore, participants discussed the notion that state agencies do not recognize that communities impacted by environmental injustice are not provided with adequate public health resources and are therefore not on equal footing with those communities that are not impacted by environmental injustice.

Examples of disproportionate distribution of environmental benefits included priority to clean water given to business over people, community clean-ups occurring in gentrified neighborhoods, incinerators burning trash from outside communities, earnings from energy productions leaving communities where the energy is produced, and unequal business ownership opportunities given to people of color.

Community Vulnerabilities: Corrective Injustice

The third subtheme that comprises the category of forms of environmental injustice in the “community vulnerabilities” theme is “corrective injustice.” These responses address a lack of meaningful reparations to compensate residents who experience environmental injustice. Participants stated that there is insufficient individual compensation for damages. One example was that individuals were not provided with sufficient assistance to relocate to healthier communities. Additionally, interviewees expressed that Community Benefits Agreements do not provide sufficient benefits.

Further, leaders reported that people and industries were not being properly fined or prosecuted for noncompliant or criminal polluting activities. One participant spoke to this lack of corrective justice when they said, *“It’s just frustrating that the people aren’t getting justice, even when it’s clear that they were harmed, and that their homes were harmed. Their properties were harmed. Their bodies were harmed. And it is still that difficult to get any sort of recourse for them.”*

Finally, interviewees highlighted the lack of speed of corrective processes. Two examples cited several times were that rural farmers are still litigating the contamination of cattle feed by fire retardant, and that Flint residents are still engaged in legal proceedings for government negligence during the Flint Water Crisis.

Community Vulnerabilities: Barriers to Advancing Environmental Justice

The third and final subtheme that comprises “community vulnerabilities” theme is “barriers to advancing environmental justice.” This subtheme is emergent, as the research team was not anticipating related responses. Data included in this theme takes the form of a long list of barriers individuals and organizations experience in attempting to promote environmental justice in Michigan. The most commonly cited barrier was lack of funding. This barrier is related to several different needs of individuals and organizations. Some interviewees mentioned a lack of government funding for city services or response to environmental issues. Others mentioned funding as a barrier to industries installing pollution prevention measures. Others discussed a lack of funding as a result of the government lowering taxes for corporations. Many participants also spoke of a general lack of funding for environmental justice issues, as many funders seem reluctant to fund projects and initiatives related to social justice.

A second prominent barrier mentioned was a lack of capacity of communities impacted by environmental injustice. Specific examples of a lack of capacity included lack of time, money, transportation, childcare, accessibility (due to disabilities), and compensation. One participant spoke to their lack of time and financial resources when they said, *“You are asking people who don’t have a lot of time or resources to spend their limited time and resources getting legal support, getting technical support, showing up for hearings, which is just something they are not capable of doing.”* Another participant commented on the general lack of capacity of communities when they said, *“Most of the people [advocates] don’t get paid. You’re just volunteering. It’s difficult to be able to be present for a lot of stuff. Let’s say somebody like me. I don’t have a car, and I live in a transportation desert and I don’t have a regular income. If people want you to come to a meeting, you have to figure out how to get to the meeting. I bicycle a lot, but if it’s raining, I can’t take my bike, or if it’s too cold, I can’t take my bike. If I*

don't have... sometimes some of the meetings and things they feed you and some of the things they don't. If you don't have money to eat, and you have to spend your money to get to someplace, then you don't have anything to eat at the meeting. You might have to go without eating. To sit through a meeting. But sometimes they have food."

A third commonly mentioned systemic barrier to advancing environmental justice was that vulnerable communities feel the government ignores them and their needs. This barrier was mentioned in relation to participants' perception of the strong influence of money in politics and decision-making processes. Interviewees reported a lack of political will to advance environmental justice and a feeling that the government places "money over people." One participant spoke to the feeling of being ignored by the government when they said, *"There are overarching themes of corporate entities and state and federal government not really doing their job and kind of looking the other way and ignoring the health of citizens and residents."*

According to environmental justice leaders, faulty decision-making procedures lead to pro-business revitalization strategies, commodification of essential environmental goods like water, and the privatization of city services and public infrastructures. Additionally, participants highlighted the lack of a state environmental justice plan and a lack of both a definition of environmental justice and criteria to distinguish environmental justice communities. An interviewee spoke to the lack of a state-level plan when they said, *"The problem is that it is all ad hoc, so it first of all forces the environmental justice community to ask for these things every single time as opposed to the DEQ by default just providing them and it's never clear what's adequate and what's sufficient. Which vital documents should be translated, and which shouldn't. Which populations count as EJ communities and which don't, what amount of time, is there a ceiling, what appropriate amount of time should you ask for in addition to these circumstances, there is no uniformity to the application of EJ in terms of the DEQ because there is no document to go off of."* Finally, participants reported some barriers that specifically affect environmental organizations. These barriers include a lack of diversity, divided community efforts, and a perceived divide between urban and rural communities.

Tools

The “tools” theme describes tools that leaders use or with which leaders are familiar. This theme includes subthemes “Existing tools,” “EJScreen use,” “Michigan tool recommendation,” and “reporting mechanisms.”

Tools: Existing Tools

The most commonly mentioned tools were EJScreen, the Michigan Department of Environmental Quality, community organizations, and existing environmental laws and policies. The matrix below provides a comprehensive list of all tools mentioned during the thirty interviews.

Tools			
Instruments	Technical	Organizations	Legal
Written record (articles, books, news, social media posts, government reports) Photoshop (designing materials) Text tree system Email system Phone outreach Mail campaign/survey Door-to-door outreach Media Social media Newsletters PowerPoint Websites Music Art Community created media Photos Events Community based participatory research Citizen science Popular education Story mapping Community asset mapping	Mapping tools Expert consultation Health, technology, and engineering analysis Modeling Soil testing Monitors in homes/schools/churches Drones flying over agricultural areas Data Academic partnerships EJScreen (https://www.epa.gov/ejscreen) NIH tox map (https://toxmap.nlm.nih.gov/toxmap/app/) CAPHE study (http://caphedetroit.sph.umich.edu) Toxics Release Inventory (TRI) data (https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools) Fractracker https://www.fractracker.org/map/national/	Department of Environmental Quality (MDEQ) Department of Health and Human Services United States Environmental Protection Agency (US EPA) Michigan Civil Rights Commission Local government State agencies Community organizations Community input Grants School curriculum Local library Coalitions Alliances	Pro-bono lawyers Environmental laws Local law Civil rights law Elliott-Larsen Civil Rights Law Policy Freedom of Information Act (FOIA) Lobbying

Table 6. Matrix displaying all tools mentioned during interviews.

Tools: EJScreen Use

When asked about utilization of US EPA's EJScreen in particular, the majority of participants said they had not used or were not aware of it. Of those who had used it, 50% reported having used it recently and 50% reported they had either not used it recently or had only used it a few times. The main reasons leaders had not used EJScreen were either lack of awareness or difficulty learning to use it. Many reported that trainings on how to utilize the tool would be helpful. Most participants were unable to comment on whether they thought EJScreen accurately measures the risks and impacts of communities.

Tools: Michigan Tool Recommendation

When asked about their thoughts on the Environmental Justice Workgroup's recommendation to create a spatial analysis tool specific to the state of Michigan (Environmental Justice Work Group 2018), a majority of the participants stated that they were familiar with the recommendation, and in favor of the creation of a tool. There were a few participants who were not aware of this recommendation and one participant who was not interested in the creation of a tool. Several participants stated that the creation of the workgroup and the recommendations delivered were not necessary given that there was an existing environmental justice plan created in 2010. Their opinion was that the recommendations distracted from the implementation of such plan.

A majority of respondents provided a caveat to the creation of the tool, stating that although a tool measuring cumulative impacts would be beneficial in terms of better measuring risks and impacts, the tool would not be effective in advancing environmental justice unless it was used to inform policy and legal parameters such as a clear definition of what constitutes an environmental justice community. According to interviewees, rules and regulations accompanying this tool would have to be developed by the State.

Finally, participants provided information regarding the reasons they thought a environmental justice screening tool specific to Michigan would or would not be helpful. Several participants shared recommendations for the tool design. These results are organized and visualized in Table 7 below.

Leaders' Considerations for a Michigan Screening Tool		
Reasons it Would be Helpful	Reasons it Would not be Helpful	Recommendations for Design of the Tool
*Would provide access to data on cumulative impacts Could better represent EJ issues specific to Michigan communities Could define EJ communities Other states have developed tools Could include health data Importance of data in advancing EJ Bridge quantitative and qualitative divide Funded by and maintained by DEQ Bring issue informally to the State Provides some evidence Good for policy and legislative development Good for sociological research and analysis Need for a regional approach	*Only helpful legally if legal standards are in place A tool is only as good as the data you have to work with it Digital divide Lack of political will People not knowing how to use the results Lack of causal analysis Information may be harmful to community	Needs to display cumulative impacts Include indoor air quality Display Native boundaries and heritage sites Definitions (such as English proficiency) are compatible with US Department of Justice and US EPA User-friendly interface Easy for general public to interpret User-friendly for non-native English speakers Built in tutorial or instructional video Dictation available (accessibility options) Use small spatial scale that you are able to increase to larger scales (county, tri-county) Could have social media reporting mechanism (signal detection) Need parsed data

Table 7. Matrix displaying all considerations for a Michigan-specific environmental justice screening tool mentioned during interviews.

*This was the most frequently mentioned reason.

Tools: Reporting Mechanisms

A second recommendation of the Governor's Environmental Justice Workgroup was to develop a reporting mechanism so impacted communities could report environmental incidents (Environmental Justice Work Group 2018). Interview participants were asked about processes that community members currently use to report an impact or exposure such as dust, contaminated waters, etc. The majority of participants did not know of a clear and efficient way to report these issues. Participants often cited MDEQ's emergency phone line, but expressed that it was not efficient or transparent, and that there was poor follow up. Other participants expressed that a clear way to report issues and receive follow up was non-existent. Other frequently cited

processes included contacting community or environmental organizations, or contacting local governments, including tribal governments. All reporting mechanisms currently available to Michigan residents according to interviewees are listed in the table below.

Ways to Report Environmental Issues
MDEQ emergency number EJ organizations Local governments Tribal governments Elected representatives Neighborhood associations Community-developed apps 211, 311, 411 US EPA (dismantled) Police Health department Social media Law firms DTE (about gas) Community leaders MI Public Service Commission

Table 8. All currently available reporting mechanisms in the state of Michigan.

A summary of themes, subthemes, and most frequently mentioned codes from all thirty interviews with environmental justice leaders is displayed below in Table 9.

Themes	Subthemes		Most Frequently Mentioned Code
Community Assets	Recent Wins		<i>Increased community engagement/action</i>
	Community Strengths		<i>Positive community relationships</i>
	Resources		<i>Community organizations</i>
Community Vulnerabilities	Risks and Impacts	Environmental Impacts	<i>Poor air quality</i>
		Socioeconomic Risks and Impacts	<i>Gentrification</i>
		Health Risks and Impacts	<i>Cancer</i>
	Forms of Environmental Injustice	Procedural Injustice	<i>Lack of government transparency</i>
		Distributive Injustice	<i>Pollution in communities of color</i>
		Corrective Injustice	<i>Lack of prosecution of polluters</i>
	Barriers to Advancing Environmental Justice		<i>Lack of funding</i>
Tools	Existing Tools		<i>EJScreen</i>
	EJScreen Use		<i>Has not used</i>
	Michigan Tool Recommendation		<i>In favor of tool</i>
	Reporting Mechanisms		<i>MDEQ emergency hotline</i>

Table 9. Summary of all themes, subthemes, and most common codes from interviews.

Chapter 5: Quantitative Analysis Methodology

This chapter describes the methodologies the research team used for quantitative data collection and analysis. Quantitative methodologies included comparing screening tool used by the US Environmental Protection Agency (US EPA), Minnesota Pollution Control Agency (MPCA), and California Environmental Protection Agency (CalEPA); accessing and preparing Michigan-specific social and environmental datasets; and statistically and spatially analyzing these datasets according to methodologies used by MPCA and CalEPA. Each step of these quantitative methodologies is described below.

5.1 Quantitative Research Questions

The quantitative portion of this study sought to answer the following research questions:

- What data can be used to quantify the state of environmental justice in Michigan?
- How accessible and available are data relevant to environmental justice?
- What gaps exist in the data regarding availability and accessibility?
- What is the feasibility of developing a Michigan-specific environmental justice screening tool based on the availability of relevant data?
- What could the application of such a screening tool reveal about the state of environmental justice in Michigan?

To answer these questions, the research team compared the data and methodologies used in screening tools from the United States Environmental Protection Agency (US EPA), the California Environmental Protection Agency (CalEPA), and the Minnesota Pollution Control Agency (MPCA). Through this comparison, the team identified the data that was both relevant and accessible for analysis of environmental

justice in Michigan, as well as data that was not available or accessible. The team prepared social data from the US Census Bureau’s American Community Survey (ACS) and US Department of Housing and Urban Development’s Community Housing Survey, as well as environmental data from US EPA’s EJScreen for analysis in ESRI’s ArcMap according to two methodological approaches. The first approach utilized the MPCA’s methodology. The second approach utilized CalEPA’s methodology without and with race and ethnicity data, respectively. Finally, the team created a map that incorporates best practices of both agencies to deliver a comprehensive assessment of the state of environmental justice in Michigan.

Following the comparative analysis of data and methodologies, as well as the creation of a map that reflects the state of environmental justice in Michigan, the team uploaded datasets used in their final map onto ArcGIS Online to create a Michigan-specific screening tool. This map can be accessed at:

http://bit.ly/MI_EJscreen.

5.2 Comparison of Screening Tools

A matrix was created to compare the indicators used in the screening tools from US EPA, CalEPA, and MPCA. In this matrix, indicators used by US EPA, CalEPA and MPCA were compared. EJScreen indicators were used as a baseline because its data is openly accessible and routinely updated. The furthest-left column of the matrix consisted of a list of indicator categories: environmental, socioeconomic, and health. Environmental indicators were further divided into three subcategories: air quality, water quality, and pollution. The specific indicators were then listed under the three categories and subcategories. The three agencies’ spatial analysis tools were listed in the top row of the matrix so that the presence or absence of each indicator could be clearly noted for each tool. Then, the “metric” and “source” for each indicator were listed for each of the three screening tools. The “metric” column for each indicator contained additional information explaining what exactly the indicator was measuring. The “source” column contained information on the agency responsible for publishing the data and the most current year of available data. See Table 10 below for the general setup of this matrix.

Tool	US EPA EJScreen		CalEPA CalEnviroScreen		MPCA			
					Story Map		What's in my Neighborhood	
Indicator	Metric	Source	Metric	Source	Metric	Source	Metric	Source
Environmental Indicators								
Air Quality								
<i>Ex: Ozone</i>								
Socioeconomic Indicators								
Income								
<i>Ex. 200% of FPL*</i>								
Health Indicators								
<i>Ex. Asthma</i>								

Table 10. Skeleton of the matrix comparing indicators used in agencies' screening tools.

**Federal Poverty Level*

By setting up the matrix in this way, the team could visually compare the indicators used in all three agencies' tools. When an indicator was found to be present in a screening tool, the cell containing that indicator was shaded green in the matrix. For environmental indicators, the team used two shades of green, light and dark, to distinguish between those indicators that represented discrete counts of polluting facilities and quantifiable risk of exposure, respectively. Alternatively, when an indicator was found to be absent from a screening tool, the cell containing that indicator was shaded pink. Cells for the subcategories themselves, such as "Health Indicators," were also shaded to reflect whether that subcategory was included in the agency and/or screening tool's methodology.

As an illustrative example, EJScreen uses an environmental indicator containing data on National Air Toxics Assessment (NATA) Air Toxics Cancer Risks. Based on how this indicator is listed in the EJScreen technical documentation, it is categorized under the category “Environmental Indicators” and subcategory “Air Quality” (US EPA 2017a). The row for NATA Air Toxics Cancer Risks reflects that the indicator is present in EJScreen, but not in CalEnviroScreen or in Minnesota’s tools, as shown by the respective green and pink shading in Figure 10 below. Further, the row is shaded dark green, which reflects that this indicator is a quantifiable measure of risk of exposure. It is also of note that “Air Quality” is absent from Minnesota’s “Story Map” tool as shown by the pink shading below. See [Appendix D](#) for the complete matrix.

Indicator	US EPA's EJ Screen		Cal EPA's CalEnviroScreen		Minnesota PCA's			
	Metric	Source	Metric	Source	Story Map		What's In My Neighborhood	
					Metric	Source	Metric	Source
Environmental Indicators								
Air Quality							Permits for facilities that emit air pollutants	MPCA
NATA Air Toxics Cancer Risks	lifetime cancer risk from inhalation of air toxics	EPA NATA (2011)						

Figure 10. Sample of indicator comparison matrix.

5.3 Identification of Usable Data

In addition to comparing the data present in each of the three screening tools of interest, the availability and utility of supplemental, Michigan-specific data was assessed. Relevant state departments and agencies were contacted regarding the accessibility of environmental and health data. Emails were sent to the Michigan Department of Health and Human Services and the Michigan Department of Environmental Quality to request access to specific datasets. As discussed later in more detail, the team was unable to obtain useful

information within a timely manner for the purposes of this study. Ultimately, the decision was made to use open-access data from the US EPA's EJScreen, US Census Bureau's American Community Survey (ACS), and the US Department of Housing and Urban Development's (HUD) Comprehensive Housing Affordability Strategy (CHAS) survey for the analysis.

5.4 Preparation of Social and Environmental Data

The team had to find and prepare the social and environmental data before they were able to statistically and spatially analyze it. Social and environmental data were prepared separately. It should be noted that the various agencies from which data were gleaned use different names for the indicators they use in their screening tools. For example, while EJScreen uses an indicator called "Less than high school education," CalEnviroScreen uses an indicator called "Educational Attainment," both of which measure percent of the population over age 25 whose education is less than a high school diploma.

5.4A. Social Data

First, the research team downloaded US census tract cartographic boundaries at a 500 kilometer resolution from the US Census Bureau. These data came in the form of a shapefile within a geodatabase that could be used in ESRI's ArcMap spatial analysis program. A field was added to the shapefile and titled "Original Area." Using the "Field Calculator" function in ArcMap, the team set the new field equal to the "Shape Area" to create a replicated column for area of each tract. In addition to that shapefile, a shapefile for "American Indian/Alaska Native Areas/Hawaiian Home Lands" was downloaded at the same resolution of 500 kilometers.

Next, the team prepared the data for social indicators, referred to as "Population Characteristics" by CalEPA and "Demographic Criteria" by MPCA. The team used the US Census Bureau's American FactFinder to find and isolate data specific to the state of Michigan for each of the social indicators used in either CalEnviroScreen or the MPCA's screening tools. These data are downloadable online in an Excel file and

represents five-year estimates that cover the years 2013 to 2017. These data were selected because they are newer than the EJScreen social data, which cover years 2011 to 2015. The most recent CHAS data from the US Department of Housing and Urban Development, which were used to quantify housing burden, cover years 2011 to 2015 and were derived from custom US Census Bureau.

Next, the team applied the methodology for excluding data based on the margin of error of each “Population Characteristic” calculation in each geographic unit referenced in the CalEnviroScreen’s technical document. While MPCA and US EPA did not use such a rigorous elimination method for ensuring the accuracy of US Census data, the team decided to apply CalEPA’s method to all social data they analyzed.

This process involved comparing the estimate of the “Population Characteristic” of interest to the margin of error for that geographic unit. For each block group, the team compared the calculated estimate of the social indicator to the standard error for the total population of that block group. Next, the team compared the standard error of each block group to the criteria used by CalEPA to determine the accuracy of the data contained in each unit. Standard error was calculated by dividing the margin of error of the unit’s total population by 1.645, the statistical value associated with the 90% confidence interval for a given estimate. The comparison then involved dividing the standard error of each unit by its estimate for a specific social indicator and accepting that unit’s data only if the resulting value was either below 50% or if that unit’s standard error was less than the average standard error for all units for that indicator estimate.

As an illustrative example, the social indicator unemployment was calculated for each block group by subtracting the number of non-institutionalized persons 16 years and older who were not employed from the total number of non-institutionalized persons 16 years and older. This calculation was the estimate for unemployment. The margin of error of the total population was given for each individual block group in number of persons. This number was divided by the total population number to give a margin of error as a percent. This number was then divided by 1.645 to get the standard error. This standard error was then divided by the estimate described earlier to get a resulting proportion. When that value was greater than 50%, the

variable was excluded unless that block group's standard error was less than the average standard error of that indicator for all block groups.

For each social indicator, the data exclusion rate was high. For example, for the social indicator unemployment 65% of all block groups were excluded through the application of this method. More than half of the social indicators had exclusion rates above 50%. For this reason, the team did not use the block group level for analysis of social indicators.

Given the lack of accuracy present for data at the block group level, the team assessed the exclusion rate of data at the census tract level. It should be noted that census tract is the level of analysis used by CalEPA for the agency's CalEnviroScreen tool. The team used the same process detailed above for data at the census tract level instead of the block group level. For more than half of the social indicators, including unemployment, the percentage of excluded census tracts was below 10%. For this reason, the team decided to analyze social indicators at the census tract level instead of the block group level.

The team then compiled one master file with calculations for the social indicators for each Michigan census tract, leaving blank the values of indicators in census tracts where the inclusion criteria was not met. The social indicators that the team analyzed are listed below in Table 11 along with their Variable IDs, as assigned by the US Census Bureau. Finally, the team uploaded this master Excel file into ArcGIS. Data on "Population Characteristics" was joined to the census tract boundary file using the geoID of each census tract as a key. The joined data was then exported as a new layer.

Indicator Name	Description of Indicator	US Census Variable ID
Percent Minority	Percent minority (100% minus % non-Hispanic white)	B03002
Educational Attainment	Percent of the population over age 25 with less than a high school education	B15003
Poverty	Percent of the population living below two times the federal poverty level	S1701
Unemployment	Percent of the population over the age of 16 that is unemployed and eligible for the labor force, excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty	S2301
Linguistic Isolation	Linguistic isolation (percent of households who speak English as a second language less than “very well”)	B16001
Housing Burdened Low-Income Households	Housing burden data from the US Department of Housing and Urban Development (HUD) (percent of households in a census tract that are both low-income (making less than 80% of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50% of their income to housing costs))	N/A

Table 11. Social indicators and their assigned variable IDs.

In addition to the “Population Characteristics” analyzed by CalEPA in CalEnviroScreen, the team decided to include minority status (represented by percent minority) based on several factors. The literature discussed in [Chapter 2](#) highlighted the importance of minority status when considering environmental justice. The MPCA also used minority status to identify that state’s “areas of concern for environmental justice” (MPCA 2015). Lastly, the results of the qualitative portion of this study, discussed in greater detail in [Chapter 4](#) of this paper, indicated that race and ethnicity are important themes to environmental justice leaders in the state of Michigan. It should also be noted that while CalEPA does not analyze minority status, the US EPA does include minority status in its calculation of environmental justice indices for its EJScreen tool. Once data on social indicators were ready, the team prepared the data on environmental indicators.

5.4B. Environmental Data

The environmental data analyzed in this study were accessed from the US EPA. A description of each variable, its unit of geographic resolution, and the most recent year accessible is available on the US EPA’s website, as well as in the indicator comparison matrix available in [Appendix D](#) of this report. These indicators are similar to those that constitute the “Pollution Burden” component of the CalEnviroScreen methodology (Faust et al. 2017).

Six of the eleven indicators were present at the census block group level. Given that the social indicators were prepared at the census tract level instead of block group level due to data quality issues, further preparation was necessary to convert the block group level data to the census tract level. However, since the indicator for lead paint can be sourced from the US Census Bureau in exactly the same way as the social indicators are, the team chose to prepare that specific indicator according to the methodology discussed above in [Section 5.4A](#). For those environmental indicators that were present at the census tract level, values were not changed. The methodology for converting census block group data to the census tract level is discussed following Table 12 below.

US EPA EJScreen			
Indicator	Metric	Source	Geographic Unit
National-Scale Air Toxics Assessment (NATA) Air Toxics Cancer Risks	Lifetime cancer risk from inhalation of air toxics	US EPA NATA (2011)	Census tract
NATA Respiratory Hazard Index	Ratio of exposure concentration to health-based reference concentration	US EPA NATA (2011)	Census tract
NATA Diesel Particulate Matter	Diesel particulate matter level in air (micrograms per cubed meter)	US EPA NATA (2011)	Census tract
Particulate Matter (PM 2.5)	Annual average PM2.5 levels in air obtained through a fusion of model and monitor data (micrograms per cubed meter)	US EPA Office of Air and Radiation OAR (2014)	Census tract
Ozone	Seasonal average of daily maximum 8-hour concentration in air obtained through fusion of model and monitor data (ppb)	US EPA OAR (2014)	Census tract
Traffic Proximity and Volume	Count of vehicles (AADT, average annual daily traffic) at major roads with 500 meters, divided by distance in meters (calculated from 2014 US DOT traffic data)	US Department of Transportation (DOT) (2014)	Census block group
Wastewater Dischargers Indicator (Stream Proximity and Toxic Concentration)	RSEI modeled Toxic Concentrations at stream segments within 500 meters, divided by distance in km (calculated from RSEI modeled toxicity-weighted stream	US EPA (2017)	Census block group

	concentrations)		
Proximity to Risk Management Plan (RMP) sites	Count of RMP facilities (facilities with a chemical accident management plan) within 5 km (or nearest one beyond 5 km), each divided by distance in km (calculated from US EPA RPM database)	US EPA (2017)	Census block group
Proximity to Hazardous Waste Facilities	Count of hazardous waste facilities (TSDFs and LQGs) within 5 km (or nearest beyond 5 km), each divided by distance in km (calculated from US EPA Resource Conservation and Recovery Act info database)	US EPA (2017)	Census block group
Proximity to National Priorities List (NPL) sites	Count of proposed and listed NPL - also known as superfund - sites within 5 km (or nearest beyond 5 km), each divided by distance in km (calculated from US EPA Comprehensive Environmental Response, Compensation, and Liability Information System database)	US EPA (2017)	Census block group
Lead Paint Indicator	Percent of housing units built pre-1960 (calculated based on US Census data)	American Community Survey (2013-2017)	Census block group (also available at the census tract level from US Census Bureau)

Table 12. Environmental indicators used in EJScreen (US EPA 2018b).

To begin the preparation of environmental data, the team downloaded the most recent versions of the US EPA's EJScreen data from the US EPA's website (US EPA 2018b). These data were in the form of both a geodatabase (.gdb) file and a comma-separated value (.csv) file. Both file types included data on all

environmental indicators for every census block group in the US. The team used Microsoft Excel to open the .csv file where Michigan block groups were then isolated using the Excel's "Filter" function and the State of Michigan's Federal Information Processing (FIP) code "026." Only the identifying data and original data for the environmental indicators present in EJScreen were included. All other data columns were eliminated.

The US Census Bureau's block-group level cartographic boundary shapefile, which had already been downloaded to access social data, was then uploaded into ArcMap. These data were at the 500 kilometer resolution. The EJScreen .csv file was also uploaded into ArcMap. The team then joined the EJScreen file to the block-group boundary shapefile and exported the joined datasets as a new map layer. The "Identity" function in ArcMap was then used to combine the new shapefile containing EJScreen data by block group with the shapefile containing census tracts and social indicators. The output of that process resulted in a new layer that contained the area of each block group within a census tract, the original area of each census tract, and all relevant environmental and social indicators. The team then exported this table in Excel format.

In Excel, a new column was created and set equal to the proportional area of each block group divided by the original area of the census tract that contained said block groups. This provided an area-weighted proportion of each census tract according to how much of its area was present in a given number of block groups. New columns were then made for each of the environmental indicators except for lead paint. The new values were the product of the original block group's proportional area and the block group's score for that indicator. As an illustrative example, imagine in a given census tract there were two block groups. One block group accounted for 60% of the area within the census tract. The other accounted for 40%. The first block group's score for a given indicator was multiplied by 0.6 and the latter by 0.4.

The team then created a Pivot Table in Excel from this new datafile where the data was sorted into rows by census tract ID. The column values were made to equal the sum of values for each environmental indicator. The resulting table consisted of one column of census tract IDs and subsequent columns for each indicator by census tract where the scores represented area-weighted values. The table was sorted by census tract ID in

descending order and copied into a new Excel file. That file was then uploaded into ArcMap and joined to the census tract shapefile with social indicators. The joined data were then exported to a new layer in ArcMap, which represented each census tract with scores for social indicators and area-weighted environmental indicators.

It should be noted that the area-weighted apportionment method was used due to data unavailability. The majority of EJScreen environmental indicators were available at the census tract-level; however, five of the eleven indicators were available only at the block group-level: (1) Traffic Proximity and Volume, 2) Wastewater Dischargers Indicator, 3) Proximity to Risk Management Plan (RMP) sites, 4) Proximity to Hazardous Waste Facilities, and 5) Proximity to National Priorities List (NPL) sites. To overcome this inconsistency in geographic scale, data for every indicator would need to be analyzed in its raw form, such as directly from data collection programs like the EPA's Toxic Release Inventory (TRI). However, this highly technical and labor intensive process was beyond the scope of this research project and is a step that should be undertaken by a well-resourced state agency as was done in the state of California.

Because social indicators were analyzed at the census tract level, the team had to aggregate the five environmental indicators available at the block group level to the census tract-level. Area-weighted aggregation was selected as the methodology to apportion values for those indicators to a census tract-level. The team acknowledged that there are several issues with using an area-weighted apportionment method, as it can result in the under or over-valuing of a specific indicator and is sensitive to the geographic distribution of that indicator across the unit of measurement. This decision reflected the team's most reasonable attempt to convert block group-level data to the census tract-level given constraints on the team's time and access to resources. Again, analyzing indicators in their raw form is a more desirable process and should be adopted by a well-resourced state agency in Michigan.

5.5 Spatial Analysis of Data

Social and environmental indicators for Michigan census tracts contained in the new layer were analyzed using three methodologies. The first was an application of the MPCA’s methodology for identifying “areas of concern for environmental justice.” The second was an application of CalEPA’s CalEnviroScreen methodology used to identify “disadvantaged communities.” Lastly, the final application was a combination of these two methodologies’ best practices.

5.5A. Applying MPCA Methodology for “Areas of Concern for Environmental Justice”

The research team based their first analysis on the application of the methodology that MPCA uses to identify “areas of concern for environmental justice” from Minnesota’s state policy on environmental justice. Criteria to define these areas were gleaned from Minnesota’s 2015 - 2018 Environmental Justice Framework (MPCA 2015). Minnesota’s Story Map tool is used by the Minnesota PCA during the environmental permitting process to assess whether the community surrounding the existing or proposed facility is an “area of concern for environmental justice.” To make permitting decisions, MPCA assesses whether the community, measured at the census tract level, fits at least one of the following criteria:

- Percent of non-white population is at least 50%
- “More than 40% of the households have a household income of less than 185% of the federal poverty level (FPL)”
- If the facility is within the boundaries of a “tribal community” (MPCA 2015).

Based on this methodology, the team analyzed Michigan-specific EJScreen and Census data at the census tract-level. To identify tribal communities, the US Census Bureau’s American Indian/Alaska

Native/Native Hawaiian Areas (AIANNH) data was used. The AIANNH data, downloaded as a shapefile, includes “federally recognized American Indian reservations, off-reservation trust land areas, and state-recognized American Indian reservations” (US Census Bureau 2019).

The “Search-by-Attribute” function in ArcMap was used to find those census tracts where either the minority population was greater than 50% or the proportion of families with a household income of less than 185% of the FPL was greater 40%. Every census tract that met at least one of those criteria was identified on this map. The resulting selection was then exported as a new layer to the map.

Next, the shapefile for “American Indian/Alaska Native Areas/Hawaiian Home Lands” was used to select only those tribal communities that are either contained within Michigan or intersecting the state’s boundary. Using the “Select-by-Location” function in ArcMap, tribal communities that were either within Michigan or intersecting the state’s boundary were selected. This selection was exported as a new layer to the map. To replicate Minnesota’s methodology, the two new layers were displayed together on a map of Michigan. This map is shown in [Appendix E](#).

5.5B. Applying CalEPA’s Methodology for “Disadvantaged Communities”

The research team based their second application on the methodology that CalEPA used to identify “disadvantaged communities” in the state. These communities are identified as those census tracts scoring within the top 25% of all census tracts within California based on their CalEnviroScreen scores. The team calculated scores for Michigan census tracts using the social and environmental data discussed in [Section 5.4](#). This calculation provided a relative ranking of Michigan’s census tracts by the estimated environmental justice metric of the CalEnviroScreen score. The CalEPA aggregation methodology was gleaned from the CalEnviroScreen 3.0 Report (Faust et al. 2017).

This methodology used a series of weights and multiplication to combine two components, “Pollution Burden” and “Population Characteristics,” to create a relative score that allows for comparison of California

communities in terms of pollution impacts and vulnerabilities. See Figure 11 below for indicators included in each component and subcomponent of the CalEnviroScreen score. The two components are each divided into two subcomponents. The “Pollution Burden” component consisted of “Exposures” and “Environmental Effects.” The “Population Characteristics” component consisted of “Sensitive Populations” and “Socioeconomic Factors.” The “Sensitive Populations” subcomponent of “Population Characteristics” consisted of three health-based indicators, as shown below in Figure 11. The team was unable to acquire Michigan-specific data for these three health indicators. Thus, that subcomponent was excluded, essentially making the “Population Characteristics” component and the “Socioeconomic Factors” subcomponent equivalent. This combination is shown in Figure 12.

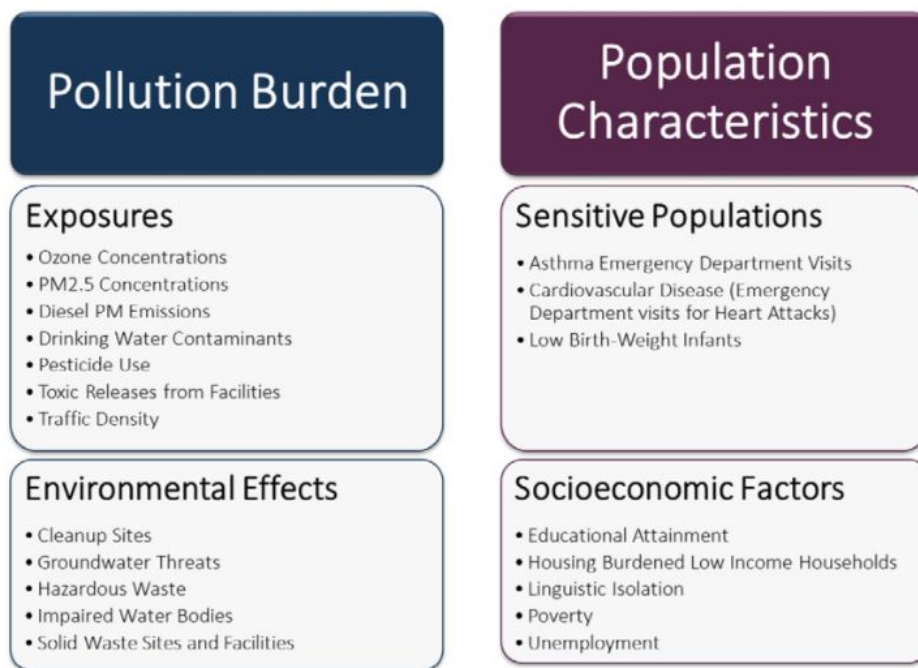


Figure 11. CalEnviroScreen score main components. Please note that this figure is taken directly from the CalEnviroScreen 3.0 Report (Faust et al. 2017).

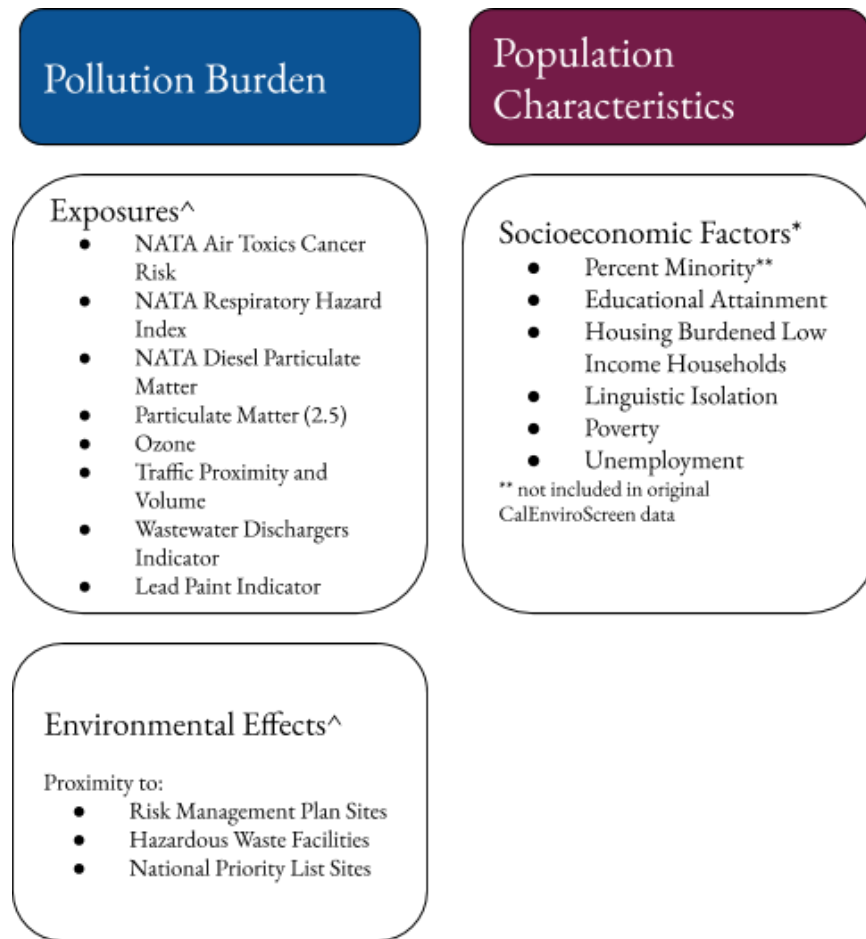


Figure 12. Main components used by the team in the Michigan-specific analysis used to calculate environmental justice scores.

[^]Data within these subcomponents used data from US EPA's EJScreen tool.

^{*}The exclusion of the health-based indicators of vulnerability included in CalEnviroScreen's "Sensitive Populations" subcomponent results in an increased weighting of "Socioeconomic Factors" within the main component of "Population Characteristics" and the overall score.

As performed by CalEPA in the CalEnviroScreen tool, the team used percentiles to address the issue of different units of measurements across individual indicators. These percentile scores for each indicator in each census tract could then be used to create scores for the subcomponents and components through the averaging of scores. However, these percentile scores were relative in that the percentile score for each indicator depended

on the range of scores for that indicator across census tracts. The percentile scores did not account for magnitude. A census tract scoring at the 50th percentile was not necessarily ten times worse off than the fifth percentile, rather the 50th percentile score is a relative ranking to the range of scores across all census tracts for that indicator.

For each census tract in the state, percentiles for all individual indicators within each subcomponent (“Exposures,” “Environmental Effects,” and “Sensitive Populations”) were averaged. For example, the percentile score for each of the three indicators listed under the “Environmental Effects” subcomponent in Figure 12 was calculated, then those three percentile scores were averaged. Then a weighted average was taken between the “Environmental Effects” and “Exposures” subcomponents to create a score for the main component of “Pollution Burden.” More specifically, the “Environmental Effects” score was first weighted by half (multiplied by 0.5), then added to the “Exposures” score. This sum was then divided by 1.5 to constitute the “Pollution Burden” score. The resulting “Pollution Burden” and “Population Characteristics” scores of each census tract were then divided by the maximum value of each score observed in the state and then multiplied by ten so that scores were scaled to have a maximum value of ten. The division by maximum value helped ensure that the two main components contributed equally to the score (Faust et al. 2017). The “Pollution Burden” score was multiplied by the “Population Characteristics” score to produce the CalEnviroScreen score for each tract. Because the maximum score for both “Pollution Burden” and “Population Characteristics” was ten, the maximum CalEnviroScreen score was one hundred, as ten multiplied by ten equals one hundred. For additional details, refer to CalEnviroScreen 3.0 Report (Faust et al. 2017). See Figure 13 below for a visual representation of the formula. Again, it should be noted that the “Sensitive Populations” subcomponent of the “Population Characteristics” component was omitted by the team due to the unavailability of health-related data for Michigan.

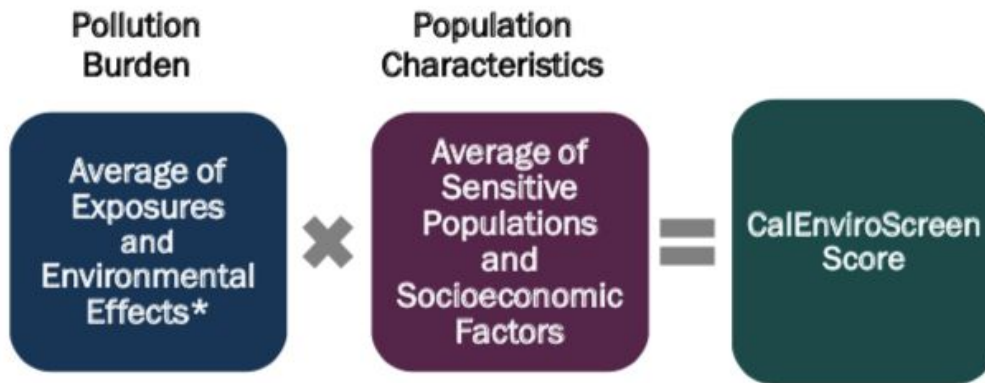


Figure 13. CalEnviroScreen calculation to obtain an environmental justice score (Faust et al. 2017).

* "Pollution Burden" is comprised of the sum of ["Exposures" score + ½("Environmental Effects" score)] all divided by 1.5.

"Populations Characteristics" score is comprised of ["Sensitive Populations" score + "Socioeconomic Factors" score] but for the team's analysis "Population Characteristics" included only the "Socioeconomic Factors" subcomponent, thus the "Population Characteristics" score equals "Socioeconomic Factors" score.

In Excel, the team calculated scores for each of Michigan's census tracts using social and environmental indicators listed in Tables 11 and 12, and Figure 12. The resulting file containing scores for each census tract was then uploaded back into ArcMap where it was joined once again to the original census tract layer using the "GEOID" attribute. Once this join was complete, the team could map each census tract by percentile and decile. This visualization was completed using the "Symbology" feature of ArcMap where the percentile value for the score was organized into deciles. The top decile was then divided into deciles to visually display the top-ten percentiles. The team also identified those census tracts whose final score fell within the top quartile (25%) of the state which reflected the methodology used by CalEPA for identifying "disadvantaged communities" (Faust et al. 2017). CalEPA also applied an additional designation for "disadvantaged communities" that may lack a sizeable population by including those census tracts who score above the 95th percentile for "Pollution Burden" but do not score in the top quartile for their overall CalEnviroScreen score (Faust et al. 2017). The results of this analysis are shown in the map in [Appendix H](#). The third and final application of methodologies to the state of Michigan focused on best practices of Minnesota and California.

Using their best practices, the team created a map depicting the state of environmental justice in Michigan and created a state-specific environmental justice screening tool.

5.6. Utilizing Best Practices to Identify Vulnerable Communities in Michigan

With the objective of assessing the state of environmental justice in Michigan by identifying vulnerable communities, the team enhanced the approach used by CalEnviroscreen by adding tribal communities as well as race and ethnicity as social indicators. This analysis reflected best practices of MPCA, CalEPA, US EPA, and the community input shown in the results of the qualitative portion of this study.

To complete this analysis, the research team combined the tribal layer from the map created according to MPCA's methodology with the layer of calculated environmental justice scores (including racial and ethnic data) based on CalEPA's methodology by pasting copies of each layer into a new map file in ArcMap. This file included the layers of: census tracts containing land belonging to tribal communities, and results of environmental justice score calculations for each census tract including racial and ethnic data.

5.7 Creating a Michigan-Specific Screening Tool: Methods

As a final step, the team uploaded data analyzed in the map described in [Section 5.6](#) to the ArcGIS Online (AGOL) platform to create an example of an interactive screening tool for Michigan. Steps followed included uploading the already prepared data to AGOL, which allows users to upload maps, including geodatabases and shapefile layers, for use in an online mapping application. The layers were then made publicly available. Modifications were made so that the data from the tool can be downloaded but the underlying data cannot be modified directly in the tool. While a reporting mechanism was not included in this tool, it would be relatively simple to add a geo-tagging function to the tool which would allow for spatial self-reporting of issues relevant to environmental justice.

Chapter 6: Quantitative Analysis Results

The results of the quantitative data analysis take two main forms: 1) a ranking of all census tracts in Michigan based on their environmental justice scores, the results of which are provided in a table and in color coded maps; and 2) an interactive environmental justice screening tool that provides details of the environmental conditions and socioeconomic characteristics of census tracts in Michigan. Intermediate steps to these two results involved creating an indicator comparison matrix and a list of datasets to which the team sought access. All results of quantitative data analysis are discussed below.

6.1 Ranking of Michigan Census Tracts

In order to inform which datasets and methodology the team used to assess environmental justice in Michigan, data and methodologies used by the United States Environmental Protection Agency (US EPA), California Environmental Protection Agency (CalEPA), and Minnesota Pollution Control Agency (MPCA) were compared. The full matrix comparing indicators used by US EPA, CalEPA, and MPCA is displayed in [Appendix D: Indicator Comparison Matrix](#). Comparing the US EPA's EJScreen, CalEPA's CalEnviroScreen, and MPCA's Story Map and What's in My Neighborhood tools by indicator showed that CalEnviroScreen is the most comprehensive of the four tools in terms of the amount of data and number of indicators used. The summary of insights gained from assessing the agencies' indicator usage is displayed below in Table 13.

Summary of indicator categories covered

<i>Indicator Categories</i>	<i>Agency and Tool</i>			
	US EPA EJScreen	CalEPA CalEnviroScreen	MPCA Story Map	What's in My Neighborhood?
<i>Environmental</i>	Used measurable exposure data for air and water quality subcategories with six and one indicators, respectively. US EPA also used a lead paint indicator. For other types of environmental burdens, such as hazardous waste facilities, the data were discrete counts of number of facilities per geographic unit. US EPA used three indicators for proximity-to-facility burdens.	Used measurable exposure data for air and water quality, as well as pesticide usage. CalEPA used four exposure indicators for air quality and one for water quality. There were two additional exposure indicators. For proximity to hazardous facilities and contaminated sites, CalEPA used five indicators.	The Story Map did not use any environmental data. This tool is used for identifying areas of concern for environmental justice and not potential for environmental exposure.	This tool used data on hazardous, permitted facilities in Minnesota. It was also the only tool to use feedlots as a facility of environmental concern.
<i>Social</i>	US EPA used seven variables across four social indicators which included race, ethnicity, age, poverty status, educational attainment, and linguistic isolation.	CalEPA used five variables for five social indicators poverty status, educational attainment, linguistic isolation, housing burden, and unemployment.	MPCA used race, ethnicity, tribal status, and poverty status.	This tool did not use social indicators.
<i>Health</i>	This tool did not use health indicators.	CalEPA used three variables for three health indicators, including asthma, cardiovascular disease, and low infant birth weight.	This tool did not use health indicators.	This tool did not use health indicators.

Table 13. Summary of indicator categories used in each tool.

As shown in Table 13, the three agencies and their tools used data across multiple dimensions of environmental justice. CalEPA's CalEnviroScreen used data for environmental, social, and health indicators. This tool was the only one to display health related data. US EPA's EJScreen used environmental and social data. MPCA's Story Map tool used social indicators to identify areas of concern, while the What's in My Neighborhood tool used permitting data to display the density of pollutive sites across the state. For the specific indicators assessed, please see [Appendix D: Indicator Comparison Matrix](#).

The accessibility of data used in all four tools was also compared. CalEPA used some data that were not publicly available in Michigan, including low-weight births and emergency department visits for heart attacks and asthma. Additionally, CalEPA used state-specific data for several environmental indicators, such as pesticide usage and drinking water contamination. While the latter is technically available through the US EPA's Safe Drinking Water Information System (SDWIS), California used additional datasets collected by the State to supplement the SDWIS data. Minnesota also used state-specific data that was collected by the MPCA. Environmental permitting data, while technically available to the public, is not easily downloadable in a format that can be used in spatial analysis. By preparing the data for use in a mapping tool such as What's in My Neighborhood, the MPCA has made the process of assessing environmental permit data more accessible for the average citizen.

Based on the results of the comparison of screening tools, the research team sought access to additional datasets relevant to the state of environmental justice in Michigan that could be used in addition to social and environmental data publicly available through the US EPA and US Census. The team contacted the Michigan Department of Environmental Quality (MDEQ) to inquire about the availability of certain environmental datasets, such as data describing drinking water quality. Additionally, the team contacted the Michigan Department of Health and Human Services (DHHS) to inquire about the availability of certain health-related datasets, such as data describing the prevalence of cardiovascular disease. Table 14 below summarizes which specific datasets were requested.

Agency Contacted	Dataset Requested	Status of Dataset
Michigan Department of Environmental Quality	Impairment and/or quality of surface water bodies used for recreation and/or drinking water (polygon-type shapefile preferred)	Provided
	Impairment and/or quality of groundwater sources used for drinking water	Available through US Geological Survey
	Drinking water quality	Not available
	Use of high-hazard, high-volatility pesticides	Not available
Michigan Department of Health and Human Services (DHHS)	Asthma emergency department visits	Provided at the zip code scale
	Cardiovascular disease	Not available
	Low birth weight - infants	Not available

Table 14. Datasets the team requested from MDEQ and DHHS.

Representatives from both the MDEQ and DHHS responded to the team’s outreach. As indicated in Table 14, the MDEQ provided data and resources related to impaired drinking water. Most of these resources, including the MDEQ’s Environmental Mapper tool, used data already available from the US EPA. The other datasets the team requested, listed in Table 14, were not readily available in a usable spatial format. The DHHS provided data related to asthma, but as the data were at the zipcode level, they were not appropriate for this study. The other two datasets requested from DHHS were not available for public use. This section of the analysis answered questions about gaps in the data available for use in a Michigan-specific environmental justice screening tool. The lack of available health data in Michigan represented a gap between data used by CalEPA and what is available in Michigan. Furthermore, the lack of data on pesticides and specific drinking water

impacts limits a complete application of CalEnviroScreen to Michigan. The team ultimately decided to use EJScreen data for environmental indicators and US Census and HUD data for social indicators as they were all publicly available and accessible, although, as mentioned earlier, some of the data had to be aggregated using an area weighted apportionment to be usable for this analysis.

The first intermediate step of the team's analysis was the application of Minnesota's "areas of concern for environmental justice" methodology to the state of Michigan. This methodology included data on tribal community boundaries, as defined by the US Census Bureau, and data on poverty, race, and ethnicity. Minnesota's methodology did not rank any census tracts. Rather, this methodology sought to highlight communities where environmental justice concerns could be present. The team provided a map in [Appendix E](#) that shows the 965 census tracts that were identified by Minnesota's methodology as being "areas of concern for environmental justice." Additionally, [Appendix G](#) includes maps delineating tribal community boundaries in Michigan as well as a table with the names of the 13 Tribal areas delineated.

The second intermediate step of analysis was the application of CalEPA's CalEnviroScreen methodology to the state of Michigan using data from the US EPA, Census Bureau, and HUD. This second analysis, which provided rankings of census tracts, first excluded racial and ethnic data due to CalEPA's omission of such data. The map created based on CalEPA's methodology can be found in [Appendix H](#). It should be noted that some census tracts fell within the top 25% (n = 686) when applying CalEPA's methodology to Michigan but were not identified as "areas of concern for environmental justice" applying MPCA's methodology (n = 275). The map highlighting these differences can be found in [Appendix F](#) displaying the location of those census tracts.

Although CalEPA does not analyze data on race and ethnicity in CalEnviroScreen, the team decided to include race and ethnicity data in their assessment of environmental justice in Michigan. As previously stated, the significance of racial and ethnic issues to environmental justice in the state of Michigan is highlighted by the qualitative analysis of this study. Furthermore, the inclusion of racial and ethnic data in both Minnesota and US

EPA’s conceptualizations of environmental justice further highlights the importance of including such data. To provide a quantitative justification for the inclusion of racial and ethnic data in the formula for calculating environmental justice scores and subsequently ranking census tracts within Michigan, the team statistically compared the tract rankings in both scenarios: 1) including racial and ethnic data and 2) excluding it. A Spearman’s rank-order correlation was calculated for the 2,741 census tracts within Michigan with the two variables being environmental justice scores using the CalEPA methodology 1) without racial and ethnic data and 2) with racial and ethnic data. The census tracts were ranked in such a way that there were no tied rankings. This no-tie ranking was accomplished by calculating final environmental justice scores for either method to four decimal places so that each tract had a unique score. These scores were then ranked and the Spearman rank-order correlation was calculated. The formula for this calculation is shown in Figure 14 below where “d” is the difference in ranking between the same tract for each methodology and “n” is the total number of census tracts. For this analysis, n was equal to 2,741.

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Figure 14. Formula for calculating Spearman’s rank-order correlation.

The resulting rank-order correlation between the two methodologies was 0.992. Given this high level of correlation and the support for including racial and ethnic data from both Minnesota’s environmental justice policies and the results of the team’s qualitative interviews, the team decided to include racial and ethnic data in the environmental justice ranking of Michigan’s census tracts. Results of this analysis are shown in Figures 15, 15a, 15b, 15c, 15d, and in [Appendix I](#).

In addition to race and ethnicity data, many interview participants highlighted the importance of including issues specific to indigenous populations in Michigan, as they felt that such issues are usually ignored. Michigan governmental bodies are already engaged in coordinating with Michigan tribal governments for a

variety of issues including water quality (Michigan.gov n.d.). Furthermore, the United States has adopted the United Nations' Declaration on the Rights of Indigenous Peoples, a resolution passed in September 2007, which affirms that indigenous peoples "should be free from discrimination of any kind" (United Nations 2007, 3). A map highlighting the 13 tribal communities within Michigan can be found in [Appendix G](#) along with a table that summarizes the locations of those communities.

The final map of Michigan (Figure 15), as well as the maps showing several of Michigan's metropolitan areas (Figures 15a, 15b, 15c, 15d), displayed two layers from data analysis: 1) results of environmental justice score calculations for each census tract including racial and ethnic data and 2) land belonging to tribal communities. These two layers reflect the Michigan-specific application of Minnesota's sensitivity to racial, ethnic, and tribal issues; the robust ranking methodology of CalEnviroScreen; and the inclusion of relevant social data based on the results of the team's qualitative inquiry. [Appendix I](#) identifies the top quartile of ranked census tracts, including their IDs and scores.

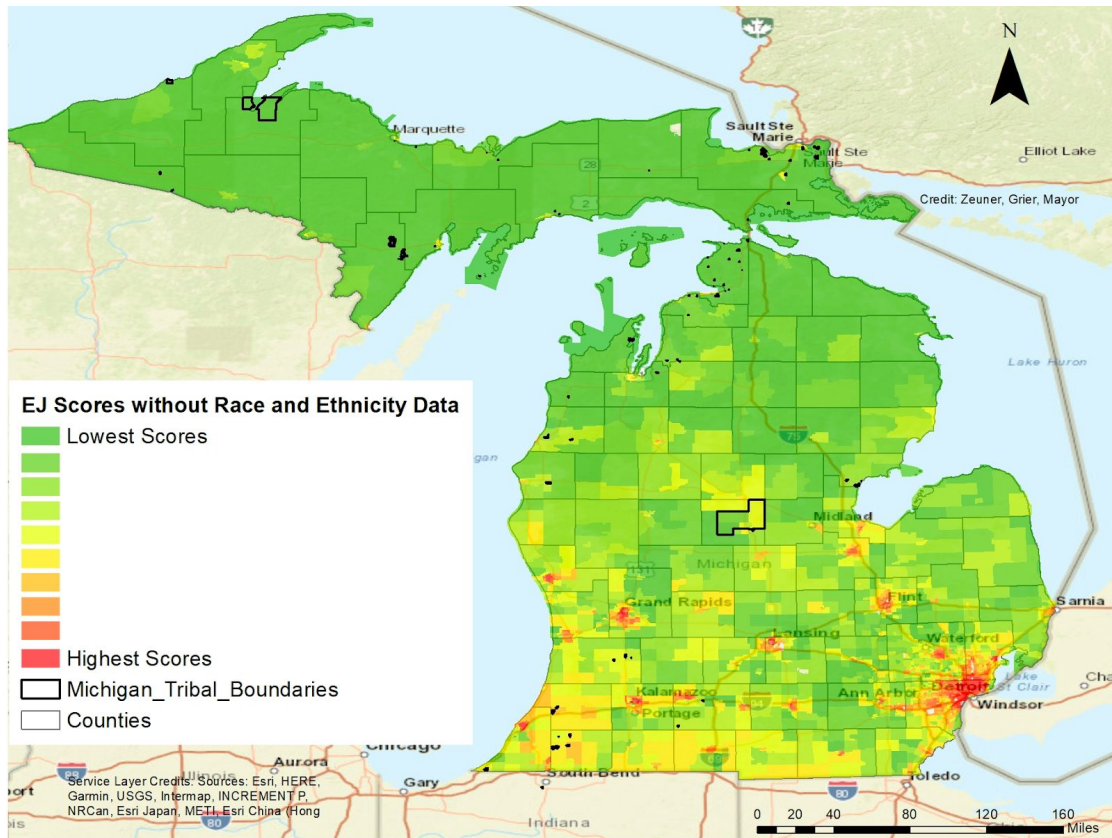


Figure 15. Final map of Michigan census tracts ranked by environmental justice scores.

The census tracts shown in the map in Figure 15 are color coded according to their relative ranking with the greenest areas being in the lowest ten percent of all census tracts by environmental justice score and the reddest areas being in the highest ten percent of census tracts by environmental justice score. An overview of the map reveals the relationship between urban areas and higher values for the team’s calculated environmental justice scores. Urban areas, such as Detroit, Grand Rapids, Flint, Saginaw, and Lansing, show a trend of “hot-spots” of environmental justice. Census tracts scoring in the top percentile are listed below in Table 15. See Figure 15a for a map of Detroit, Figure 15b for a map of Flint, Figure 14c for a map of Saginaw, and Figure 15d for a map of Grand Rapids.

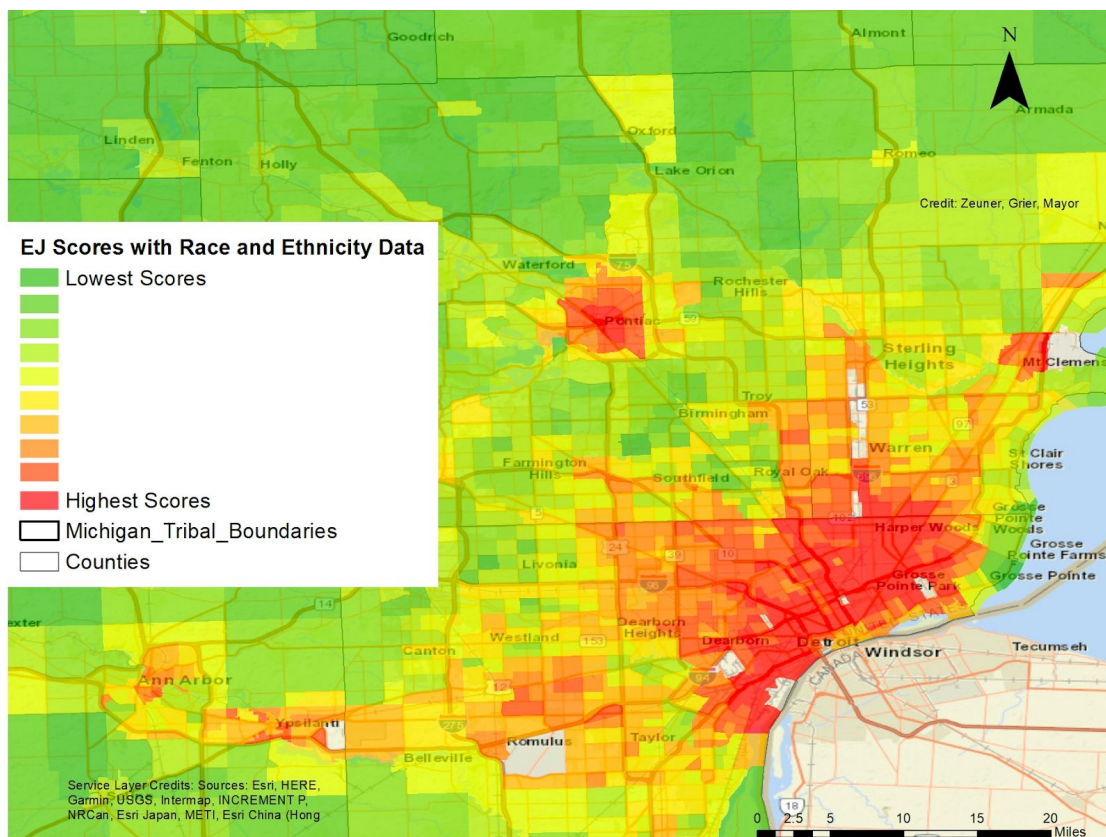


Figure 15a. Map showing Metropolitan Detroit census tracts ranked according to CalEPA's methodology (with racial and ethnic data).

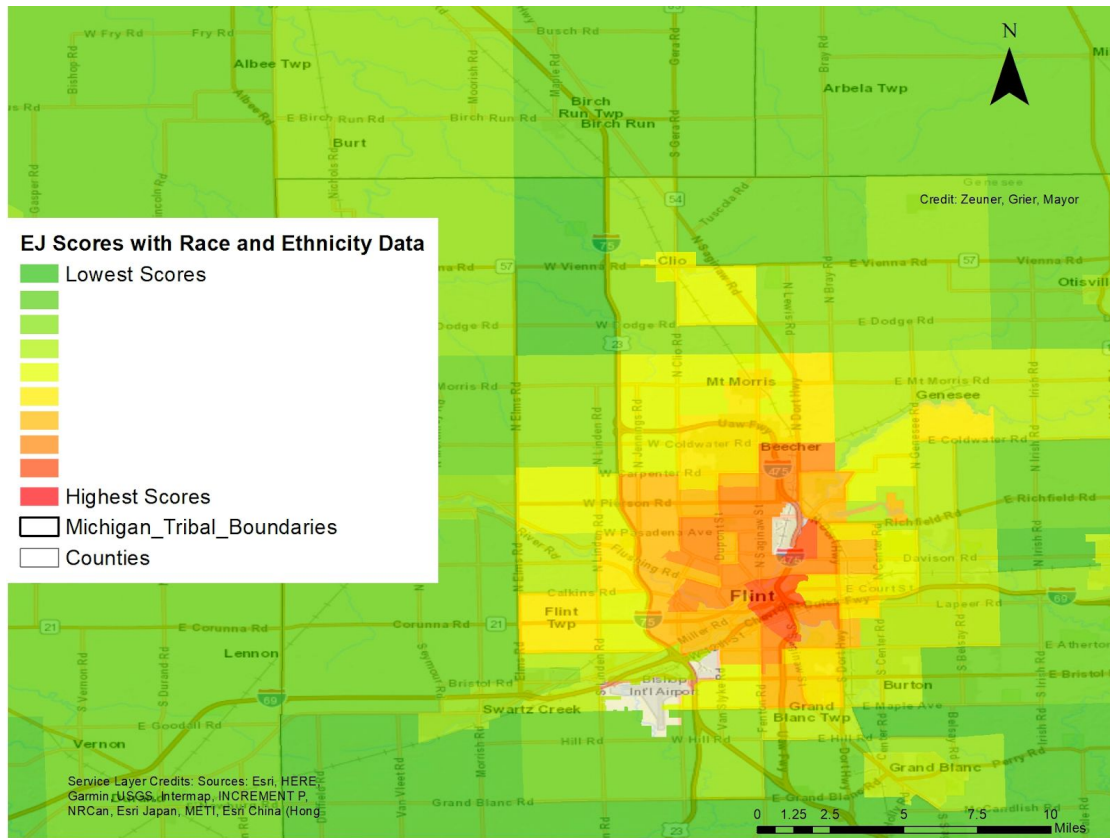


Figure 15b. Map showing Flint census tracts ranked according to CalEPA's methodology (with racial and ethnic data).

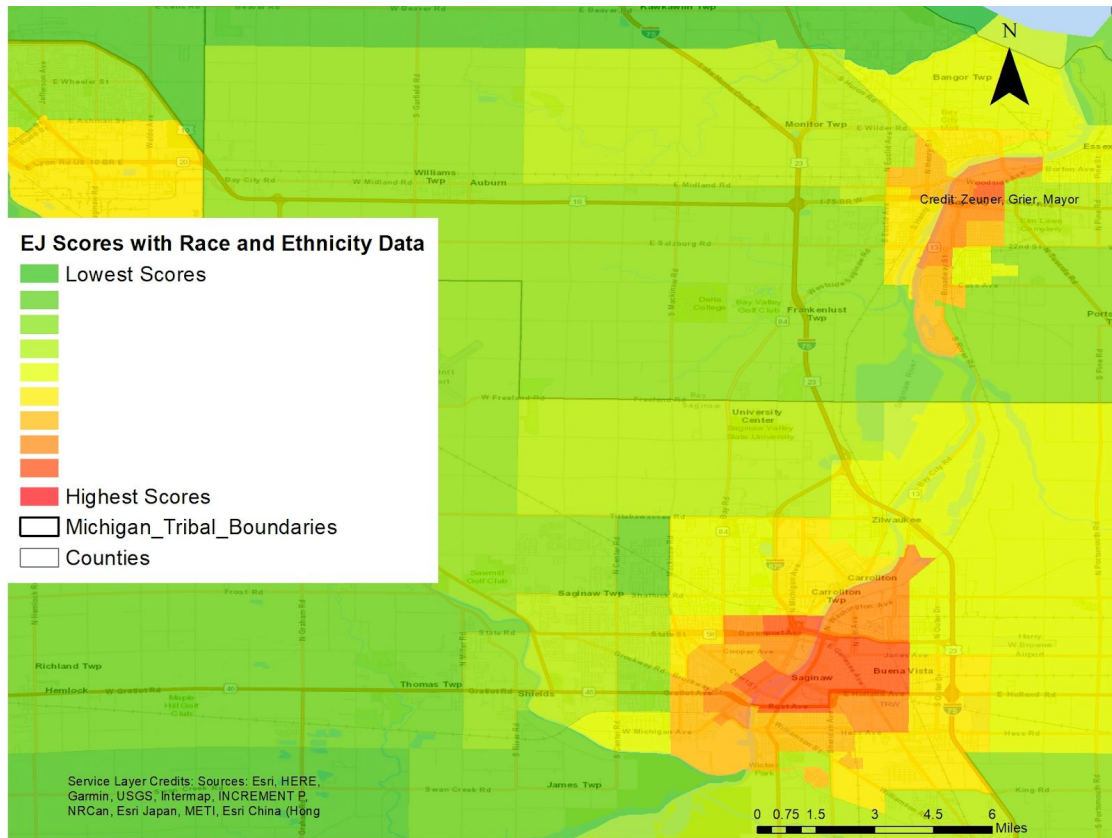


Figure 15c. Map showing Saginaw census tracts ranked according to CalEPA's methodology (with racial and ethnic data).

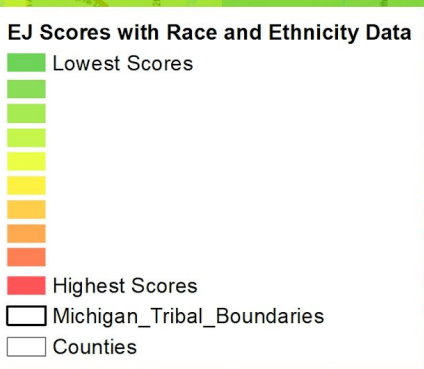


Figure 15d. Map showing Grand Rapids census tracts ranked according to CalEPA's methodology (with racial and ethnic data).

Rank	Tract	EJ Score	Percentile	County	NATA Diesel PM ($\mu\text{g}/\text{m}^3$)	NATA Air Toxics Cancer Risk (unitless)	NATA Respiratory Hazard Index (unitless)	Traffic Proximity & Volume (avg. ann. daily traffic/m)
1	0039	93.9945	99.9%	KENT	1.231	46.802	2.233	4327.280
2	0002	91.9467	99.9%	KALAMAZOO	1.048	41.275	1.854	393.773
3	0003	90.1726	99.9%	KALAMAZOO	1.230	46.196	2.269	518.654
4	0038	89.5012	99.8%	KENT	1.047	46.560	2.195	1832.734
5	0040	87.7397	99.8%	KENT	0.859	41.223	1.869	2389.538
6	0036	87.6325	99.8%	KENT	1.043	48.300	2.392	918.025
7	0026	87.4281	99.7%	KENT	0.957	43.980	2.041	1554.536
8	5061	87.2077	99.7%	WAYNE	1.485	44.631	2.060	2345.817
9	5055	86.9241	99.7%	WAYNE	1.622	41.125	1.930	5852.551
10	5162	86.6946	99.6%	WAYNE	1.389	40.285	1.754	1706.873
11	0028	86.4647	99.6%	KENT	1.004	44.675	2.057	2732.171
12	5051	85.8678	99.5%	WAYNE	1.671	41.567	1.964	1352.940
13	5189	85.2947	99.5%	WAYNE	1.836	46.368	2.121	6060.611
14	5050	84.7682	99.5%	WAYNE	1.295	39.307	1.685	1083.724
15	0001	84.7631	99.4%	KALAMAZOO	0.928	40.652	1.880	611.122
16	5032	84.7490	99.4%	WAYNE	1.576	43.205	1.894	1469.199
17	5238	84.3339	99.4%	WAYNE	1.305	54.409	1.534	3034.322
18	0037	84.1566	99.3%	KENT	1.090	46.268	2.217	1110.566
19	2638	83.9774	99.3%	MACOMB	1.535	44.379	2.065	3397.491
20	5159	83.7271	99.3%	WAYNE	2.126	45.293	2.509	4970.509
21	5047	83.6454	99.2%	WAYNE	1.618	40.511	1.955	2775.179
22	5110	83.3282	99.2%	WAYNE	1.434	40.566	1.854	2414.282
23	0009	83.2441	99.1%	KALAMAZOO	1.213	43.795	2.081	620.993
24	5054	83.1436	99.1%	WAYNE	1.652	42.260	1.983	2045.796
25	5250	82.4909	99.1%	WAYNE	1.076	63.501	1.439	1732.571
26	5142	81.0785	99.0%	WAYNE	1.775	41.482	1.925	2463.292
27	5243	80.7583	99.0%	WAYNE	1.005	50.253	1.349	1931.653
28	2639	80.7419	99.0%	MACOMB	1.504	46.840	1.896	1156.880
State Average for Indicators					0.764	31.789	1.361	687.837

Table 15. Michigan census tracts with environmental justice scores that fall in the top percentile (1%).

Rank	Tract	EJ Score	Percentile	County	Wastewater Discharge (Toxic Conc./km)	Superfund National Priority List Sites (#/5km)	Risk Management Plan Sites (#/5km)	Hazardous Waste Facilities (TSDFs) (#/5km)
1	0039	93.9945	99.9%	KENT	0.010	1.016	3.000	4.227
2	0002	91.9467	99.9%	KALAMAZOO	0.021	2.393	2.318	2.694
3	0003	90.1726	99.9%	KALAMAZOO	0.008	1.158	1.552	2.847
4	0038	89.5012	99.8%	KENT	0.004	0.889	2.133	3.848
5	0040	87.7397	99.8%	KENT	0.009	1.086	2.523	3.331
6	0036	87.6325	99.8%	KENT	0.002	0.587	1.586	4.235
7	0026	87.4281	99.7%	KENT	0.006	1.130	3.698	4.454
8	5061	87.2077	99.7%	WAYNE	0.000	0.085	5.000	2.859
9	5055	86.9241	99.7%	WAYNE	0.000	0.075	2.388	4.569
10	5162	86.6946	99.6%	WAYNE	0.000	0.056	0.854	4.923
11	0028	86.4647	99.6%	KENT	0.002	0.614	1.794	4.850
12	5051	85.8678	99.5%	WAYNE	0.000	0.083	3.360	2.800
13	5189	85.2947	99.5%	WAYNE	0.000	0.047	0.545	5.304
14	5050	84.7682	99.5%	WAYNE	0.000	0.084	2.887	2.975
15	0001	84.7631	99.4%	KALAMAZOO	0.014	2.466	1.779	2.396
16	5032	84.7490	99.4%	WAYNE	0.000	0.096	2.241	3.415
17	5238	84.3339	99.4%	WAYNE	0.343	0.042	2.925	5.451
18	0037	84.1566	99.3%	KENT	0.003	0.585	1.437	4.062
19	2638	83.9774	99.3%	MACOMB	0.000	0.057	3.623	4.099
20	5159	83.7271	99.3%	WAYNE	0.000	0.051	1.201	3.917
21	5047	83.6454	99.2%	WAYNE	0.000	0.071	1.675	3.358
22	5110	83.3282	99.2%	WAYNE	0.000	0.062	1.864	3.525
23	0009	83.2441	99.1%	KALAMAZOO	0.000	1.676	1.766	3.578
24	5054	83.1436	99.1%	WAYNE	0.000	0.077	1.459	1.918
25	5250	82.4909	99.1%	WAYNE	2.576	0.034	3.089	9.643
26	5142	81.0785	99.0%	WAYNE	0.000	0.062	1.183	3.460
27	5243	80.7583	99.0%	WAYNE	0.490	0.044	3.760	6.519
28	2639	80.7419	99.0%	MACOMB	0.000	0.098	3.132	4.333
State Average for Indicators					0.178	0.128	0.545	0.872

Table 15. Michigan census tracts with environmental justice scores that fall in the top percentile (1%)
(continued).

Rank	Tract	EJ Score	Percentile	County	Ozone (ppb)	PM 2.5 (µg/m3)	Lead Paint Indicator (% pre-1960 housing)	Percent Minority	Educational Attainment
1	0039	93.9945	99.9%	KENT	43.528	11.026	78.7%	91.9%	60.5%
2	0002	91.9467	99.9%	KALAMAZOO	44.772	11.338	78.1%	96.5%	-
3	0003	90.1726	99.9%	KALAMAZOO	44.777	11.360	69.0%	90.6%	27.0%
4	0038	89.5012	99.8%	KENT	43.523	11.028	77.5%	91.5%	55.6%
5	0040	87.7397	99.8%	KENT	43.584	11.073	76.9%	87.8%	48.2%
6	0036	87.6325	99.8%	KENT	43.449	11.030	64.6%	88.8%	40.1%
7	0026	87.4281	99.7%	KENT	43.468	11.003	69.0%	89.1%	46.3%
8	5061	87.2077	99.7%	WAYNE	44.182	11.003	93.1%	93.5%	31.8%
9	5055	86.9241	99.7%	WAYNE	44.019	11.027	90.2%	94.3%	23.2%
10	5162	86.6946	99.6%	WAYNE	43.696	11.072	90.1%	98.0%	-
11	0028	86.4647	99.6%	KENT	43.395	11.015	49.9%	84.8%	31.1%
12	5051	85.8678	99.5%	WAYNE	44.248	10.996	70.6%	93.9%	-
13	5189	85.2947	99.5%	WAYNE	43.494	11.085	-	98.1%	34.4%
14	5050	84.7682	99.5%	WAYNE	44.286	10.995	100.0%	100.0%	-
15	0001	84.7631	99.4%	KALAMAZOO	44.779	11.354	77.2%	80.4%	22.1%
16	5032	84.7490	99.4%	WAYNE	44.299	10.993	87.9%	92.0%	-
17	5238	84.3339	99.4%	WAYNE	42.800	11.152	90.2%	80.8%	35.1%
18	0037	84.1566	99.3%	KENT	43.470	11.031	86.2%	85.1%	27.5%
19	2638	83.9774	99.3%	MACOMB	44.185	11.004	79.7%	54.9%	24.2%
20	5159	83.7271	99.3%	WAYNE	43.862	11.057	88.3%	98.7%	17.9%
21	5047	83.6454	99.2%	WAYNE	43.949	11.038	92.5%	98.2%	23.7%
22	5110	83.3282	99.2%	WAYNE	43.953	11.046	73.5%	98.2%	39.2%
23	0009	83.2441	99.1%	KALAMAZOO	44.768	11.355	95.4%	44.8%	21.6%
24	5054	83.1436	99.1%	WAYNE	44.223	11.009	86.7%	96.3%	17.4%
25	5250	82.4909	99.1%	WAYNE	42.803	11.164	96.2%	60.3%	50.8%
26	5142	81.0785	99.0%	WAYNE	43.874	11.055	78.0%	99.9%	25.9%
27	5243	80.7583	99.0%	WAYNE	42.658	11.145	87.0%	78.9%	51.9%
28	2639	80.7419	99.0%	MACOMB	44.222	10.993	74.1%	40.6%	26.1%
State Average for Indicators					42.764	10.198	42.5%	29.2%	10.9%

Table 15. Michigan census tracts with environmental justice scores that fall in the top percentile (1%) (continued). Note that “Educational Attainment” represents percent of population over age 25 without a high school diploma.

Rank	Tract	EJ Score	Percentile	County	Housing Burdened Low Income Households	Linguistic Isolation	Poverty*	Unemployment
1	0039	93.9945	99.9%	KENT	28.2%	46.5%	71.3%	15.9%
2	0002	91.9467	99.9%	KALAMAZOO	27.9%	-	64.3%	28.9%
3	0003	90.1726	99.9%	KALAMAZOO	23.9%	-	59.8%	24.8%
4	0038	89.5012	99.8%	KENT	21.4%	45.9%	75.3%	14.5%
5	0040	87.7397	99.8%	KENT	21.3%	40.4%	69.4%	14.4%
6	0036	87.6325	99.8%	KENT	28.7%	20.6%	67.7%	18.8%
7	0026	87.4281	99.7%	KENT	20.3%	34.1%	75.1%	13.5%
8	5061	87.2077	99.7%	WAYNE	36.6%	-	65.0%	23.5%
9	5055	86.9241	99.7%	WAYNE	38.8%	-	72.8%	29.5%
10	5162	86.6946	99.6%	WAYNE	33.8%	-	74.9%	34.9%
11	0028	86.4647	99.6%	KENT	23.4%	22.1%	81.5%	15.0%
12	5051	85.8678	99.5%	WAYNE	36.7%	-	73.2%	33.2%
13	5189	85.2947	99.5%	WAYNE	33.8%	-	76.3%	37.2%
14	5050	84.7682	99.5%	WAYNE	27.9%	-	69.4%	36.9%
15	0001	84.7631	99.4%	KALAMAZOO	20.1%	-	67.7%	14.9%
16	5032	84.7490	99.4%	WAYNE	27.8%	-	75.6%	19.5%
17	5238	84.3339	99.4%	WAYNE	29.7%	29.4%	72.0%	14.9%
18	0037	84.1566	99.3%	KENT	27.8%	-	58.5%	11.0%
19	2638	83.9774	99.3%	MACOMB	40.1%	-	69.2%	28.0%
20	5159	83.7271	99.3%	WAYNE	34.7%	-	71.9%	27.8%
21	5047	83.6454	99.2%	WAYNE	25.8%	-	65.7%	26.9%
22	5110	83.3282	99.2%	WAYNE	26.4%	-	70.6%	41.9%
23	0009	83.2441	99.1%	KALAMAZOO	18.4%	-	73.8%	11.6%
24	5054	83.1436	99.1%	WAYNE	27.6%	-	81.3%	35.2%
25	5250	82.4909	99.1%	WAYNE	40.5%	-	83.6%	20.9%
26	5142	81.0785	99.0%	WAYNE	27.4%	-	52.6%	28.1%
27	5243	80.7583	99.0%	WAYNE	22.9%	26.3%	59.8%	25.7%
28	2639	80.7419	99.0%	MACOMB	34.0%	-	57.5%	21.3%
State Average for Indicators					14.3%	3.5%	30.8%	8.8%

Table 15. Michigan census tracts with environmental justice scores that fall in the top percentile (1%) (continued).

*The “Poverty” indicator is measured as percent of the population living below two times the federal poverty level.

Table 15 above lists those census tracts which scored in the top percentile of all Michigan census tracts when ranked by the environmental justice score. These census tracts had the highest environmental justice scores of any census tracts across the state. Based on CalEPA’s ranking system, the team highlighted the top 25% of census tracts (n = 686). A full list of Michigan’s census tracts scoring in the top 25% of environmental justice scores is provided in [Appendix I: List of Top Quartile \(25%\) Census Tracts Ranked by EJ Score](#). Designating

those census tracts that are in the top quartile and/or have land area within a tribal community could be one way to identify communities in Michigan with the potential for environmental justice concerns. It should be noted that CalEPA designates the top 25% scoring tracts as “disadvantaged communities,” not “environmental justice communities” as there is not only one tool or method that can be used to identify areas at risk for disproportionate environmental harm. Additionally, it is of note that CalEPA also designates tracts that score above the 95th percentile but do not have a “Population Characteristics” score as “disadvantaged.” From this list, which includes the host county of each census tract, one can see that Kalamazoo, Kent, and Wayne counties host nearly all of the census tracts within the top percentile with the exception of the 19th and 28th highest scoring census tracts in Macomb county (in Southeastern Michigan).

In addition to ranking the census tracts by percentile and identifying the top quartile, the team examined the overall distribution of environmental justice scores across the state of Michigan. As shown below in Figure 16, one way to examine this distribution is by looking at the difference between the average environmental justice scores of each percentile ($n = 28$ census tracts per percentile) and the median environmental justice score for the state as a whole (23.314). Figure 16 shows that the bottom half of census tracts are closer to the median score while those census tracts scoring in the upper percentiles have average environmental justice scores that are further from the median score. In theory, an equitable distribution of environmental justice scores would be one in which there is little variation from the median across all percentiles (i.e. an almost horizontal line). One potential way to measure progress in environmental justice is by comparing the results of this graph over time. In a state of perfect social and environmental equality, the distance of every percentile’s environmental justice score from the median environmental justice score would be zero, resulting in a flat line instead of a curve on this graph. Any movement towards a flat line away from such a steep curve would represent progress in the advancement of environmental justice. One possible quantitative measure would be to examine reductions in the standard deviation of the environmental justice score over time. In a perfectly equitable world, the standard deviation would be zero.

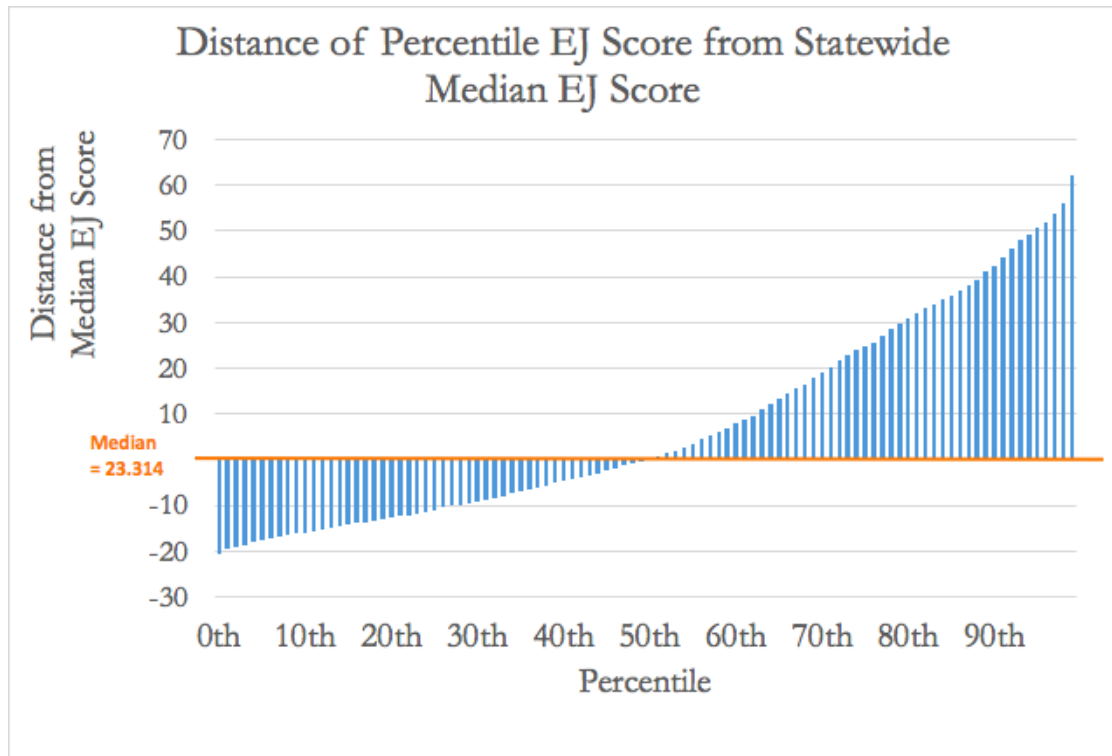


Figure 16. Graph showing the distance of the average environmental justice (EJ) score of each percentile from the statewide median EJ score.

When applying this method to quartiles, the trend that the lowest scoring census tracts are closer to the median score while the highest scoring census tracts are further from the median score remains. As shown in Figure 17, which shows the distance of quartile average distances from the median, the upper-most quartile (75%+) shows an almost 40 point difference from the state median environmental justice score. Figure 17 supports setting the threshold for identifying areas of concern at the top quartile based on the large distance between the scores of that group and the statewide median.

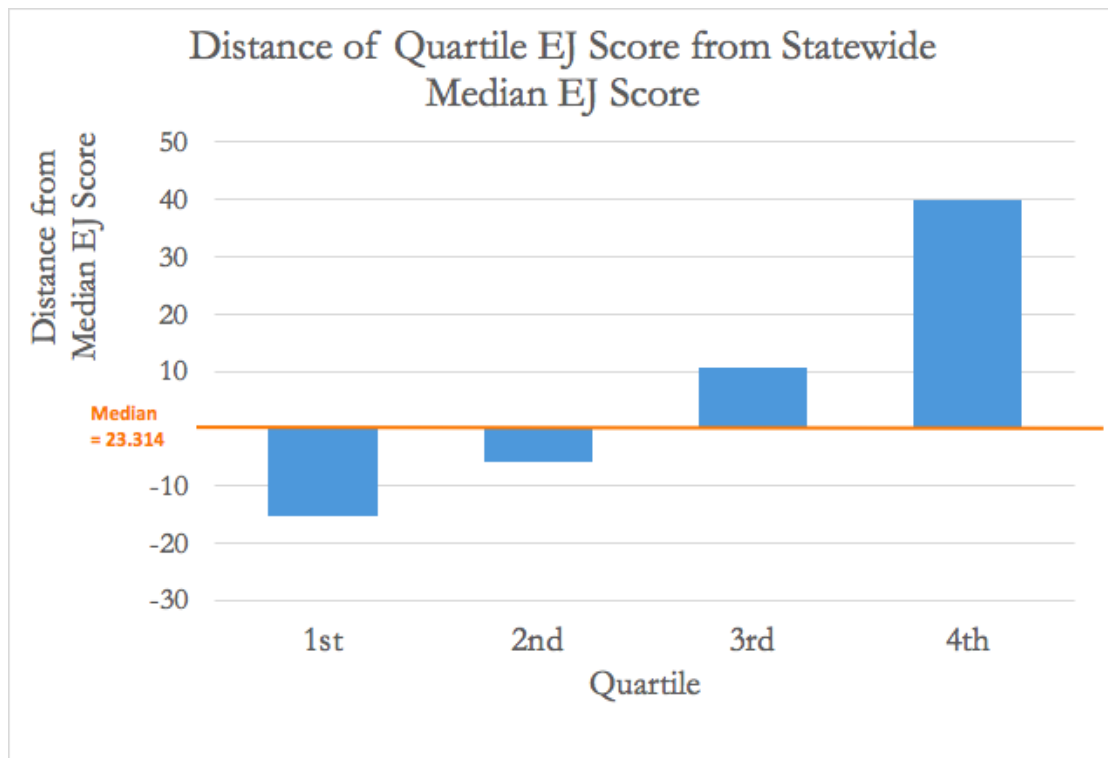


Figure 17. Chart showing the distance of the average environmental justice (EJ) score of each quartile from the statewide median EJ score.

6.2 Interactive Michigan Environmental Justice Screening Tool

In addition to providing a list of census tracts and their ranked environmental justice scores, the team sought to create a Michigan-specific environmental justice screening tool that could demonstrate the feasibility of creating such a tool for use in areas from policy to education to activism. The team used ArcGIS Online to create a user-friendly, dynamic mapping application that could be used to efficiently gauge the state of environmental justice across Michigan as well as in any specific community in the state. This tool could be used to identify and prioritize communities of significance to environmental justice in Michigan. A link to the tool can be found here: http://bit.ly/MI_EJscreen.

To provide an example of how the team's environmental justice screening tool could be used, a scenario relevant to environmental justice is presented. Imagine an industrial facility located in census tract 0039 in Kent County, the top-ranked tract in Michigan in terms of the calculated environmental justice score. Imagine the facility already emits toxic chemicals into the surrounding air and/or water and has applied for a permit through the MDEQ to increase its industrial activity. MDEQ officials charged with deciding the status of this facility's permit could enter the address of the facility into the screening tool, resulting in Figure 18 displayed below. Based on these results, officials could see that surrounding community members are already disproportionately burdened by environmental justice issues. Figures 18 and 19 show that residents of Kent County already rank in the top decile for Linguistic Isolation, Poverty, Percent Minority, Educational Attainment, Housing Burden, Proximity to Hazardous Waste Facilities, Proximity to Risk Management Plan (RMP) sites, Proximity to National Priority List (NPL) sites, Traffic Proximity and Volume, NATA Respiratory Hazard Index, and NATA Air Toxics Cancer Risk. These results could inform the agency's permitting decision pertaining this facility. In addition, this tool could inform state-level policy similar to policies of California and Minnesota wherein a threshold is set for identifying areas at risk for environmental justice issues. The quantitative ranking of Michigan census tracts provided in this tool could help the State distinguish which census tracts might need more resources and where remediation might need to be prioritized.

In addition to State government use, the tool could also be used by local governments and community members. In the case of the permit request in Kent County community members could enter the address of the facility into the tool and examine the environmental justice implications of the proposed expansion. The results could inform their public comment and advocacy efforts. Further, local governments, such as the City of Grand Rapids, could use the tool to inform zoning, permitting, and other land use decisions. For example, the City could exclude new industrial zoning in areas where a specific environmental justice threshold is passed.

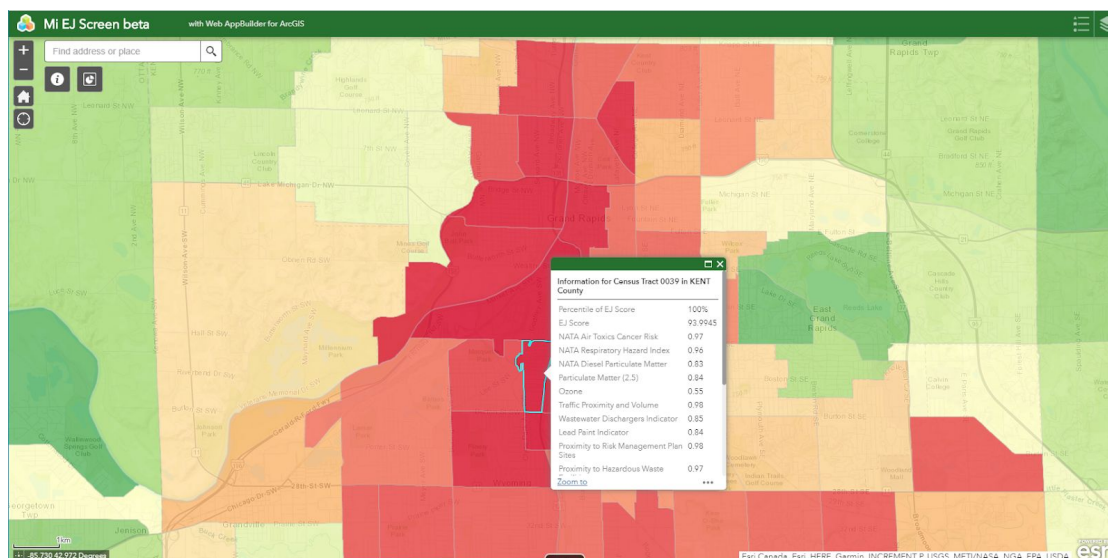


Figure 18. Screenshot of Kent County in the Michigan-specific environmental justice screening tool.

Information for Census Tract 0039 in KENT County	
Percentile of EJ Score	100%
EJ Score	93.9945
NATA Air Toxics Cancer Risk	0.97
NATA Respiratory Hazard Index	0.96
NATA Diesel Particulate Matter	0.83
Particulate Matter (2.5)	0.84
Ozone	0.55
Traffic Proximity and Volume	0.98
Wastewater Dischargers Indicator	0.85
Lead Paint Indicator	0.84
Proximity to Risk Management Plan Sites	0.98
Proximity to Hazardous Waste	0.97
Zoom to	***

Figure 19. Ranking results for census tract 0039 in Kent County, MI.

Chapter 7. Discussion

In considering how the results of the qualitative and quantitative analyses synergistically assess the state of environmental justice in Michigan, the team came to three important conclusions. First, environmental injustice exists in Michigan. Second, developing a Michigan-specific environmental justice screening tool is feasible and desired by environmental justice leaders in the state. Third, any screening tool developed needs to have state-level policy support. Each of these implications is discussed below.

7.1 The State of Environmental Justice in Michigan

Qualitative and quantitative data analysis revealed that environmental goods and harms are inequitably distributed in the state of Michigan. An interview participant explicitly addressed the state of environmental justice in Michigan when they said, *“The state of environmental justice in those communities in Michigan at least is non-existent. If the question is how much environmental justice policy do they have access to in order to advance environmental justice and overcome environmental injustice, the answer is almost none.”*

Based on interview data, environmental justice leaders perceived a statewide inequity of both access to environmental goods and protection from environmental harms that is based on both income and race. Examples of codes that spoke to inequitable access to environmental goods included clean water being provided to businesses and state employees but not residents during the Flint Water Crisis, funds being invested in cleaning up gentrified neighborhoods but disinvestment occurring in minority and low-income communities, and seeing more white than black business owners in cities. Examples of codes that spoke to inequitable protection from environmental harms included lack of consideration of indigenous populations’ use of land, incinerators located in African American communities, and fracking companies working in low-income areas. Other codes that mentioned racial discrimination, such as impacts on cultural practices, lack of funding as a

barrier to advancing environmental justice; and impacts of privatization on access to resources also spoke to this disproportionate impact.

Codes from interview data provide a window into the lived experiences of those dealing with the impacts of exposure to environmental harms and limited access to environmental goods. Despite recent wins such as building coalitions across different communities, community strengths including resiliency and connection to place, and access to resources like the US EPA and academic partnerships, communities represented in the interview data are vulnerable to environmental impacts. Environmental risks and impacts, such as exposure to pollution in the air and water, are compounded by both socioeconomic impacts, such as unemployment. Additionally, health impacts, such as asthma, make communities increasingly susceptible to environmental harm. Vulnerability is exacerbated by instances of procedural injustice, such as decision-making by emergency managers instead of elected leaders; distributive injustice, such as income earned from energy production leaving communities; and corrective injustice, such as lack of compensation for damages. A long list of barriers, such as lack of transportation and feeling ignored by the government, hold back community members' efforts of improving the health of themselves and their communities.

Interview data shows that placing the burden on impacted communities to educate themselves about technical issues is unreasonable, as is the need for these communities to have to invest their already limited resources in advocating for their health and wellbeing. Participants expressed great frustration with the governing bodies they believed were elected to protect them. Participants expressed feeling neglected by these representatives who, in their eyes, should be advocating on behalf of their constituents. These perceptions of being ignored are consistent with current research that shows indifference or apathy towards people of color is a manifestation of racial and ethnic discrimination (Forman and Lewis 2006).

Another consideration is the additional burden that advocacy places on these communities in terms of increased stress. An emergent theme in the interview data showed that community advocates expressed a considerable amount of emotional and psychological impacts. Previous research has shown that stress increases

susceptibility to disease, which further compounds vulnerability for members of these communities (Schulz and Northridge 2004).

The spatial analysis of social and environmental indicators demonstrates the existence of environmental injustice in Michigan. The map created according to best practices of both CalEPA and MPCA shows hotspots where low-income communities and communities with greater concentration of racial and ethnic minorities experience greater exposure to environmental risk and impacts. The presence of these hotspots indicates an inequitable distribution of environmental harms. The observation that every census tract in Michigan does not experience the same amount of environmental risk and exposure, and the observation that there are such differences in environmental justice scores across the geography of the state point to the existence of environmental injustice in Michigan. While this point does not represent support for a uniform dispersion of the current pollution burden across the state, it does recognize that a non-uniform pattern of environmental harms that is related to spatial patterns of social characteristics is both relevant and meaningful to the discussion of environmental justice in Michigan. Furthermore, the analysis of how environmental justice scores were distributed across percentiles and quartiles provided additional support for the claim that environmental injustice exists in Michigan. The difference between the statewide median environmental justice score and the scores of the highest scoring tracts is larger than the difference between the statewide median and the lowest scoring tracts, indicating the high relative vulnerability of communities scoring above the state median.

Finally, this assessment provides a baseline of information that will need to be updated in the future and against which progress in advancing environmental justice can be measured. The Environmental Justice Work Group's ninth recommendation proposed that the State create an annual report that evaluates the "current state of environmental justice conditions" yearly to monitor progress (Environmental Justice Work Group 2018). The Michigan specific tool created by the research team could inform this process.

7.2 Development of a Michigan-Specific Environmental Justice Screening Tool

One way the State could advance environmental justice is by adopting, maintaining, and using a screening tool such as the one developed in this study with Michigan-specific data. Qualitative and quantitative data analysis spoke to the desire, possibility, and potential use of such a tool. There are multiple approaches the State of Michigan could take to develop a tool, two of which are represented by the screening tools used in Minnesota and California.

Story Map used by the MPCA displays which census tracts are low-income, minority, or belonging to a tribal nation to identify areas that might be of concern for environmental justice. While the MPCA does not explicitly measure and quantify environmental exposure, the What's in My Neighborhood tool does provide important environmental information on permits. These tools allow the State of Minnesota to address the potential for the social determinants of environmental injustice, and are linked to policy and decision-making. Identifying vulnerable census tracts based on income, race, and tribal status is a fundamental step the State of Michigan could take in developing an environmental justice screening tool. All three indicators would be relevant to Michigan.

The State of Michigan could look to CalEPA as an example for other aspects of developing an environmental justice screening tool. CalEnviroScreen used by CalEPA displays health data along with environmental and social data, unlike MPCA's tools or EJScreen. The State of California also collects its own environmental data to display on CalEnviroScreen; several state agencies worked with CalEPA to aggregate relevant data for use in the tool. The fact that CalEPA has access to data relevant to the environmental issues in the state and specifically collected by agencies at work in the state makes their screening tool more robust, thorough, and comprehensive than it would be without this state-specific data. By CalEPA collecting its own

raw data to be used in analysis of environmental justice, it avoids having to employ data aggregation methods, such as area-weighted apportionment used in this study. Similarly, the MDEQ should consider collecting relevant Michigan-specific data in house that can be used to analyze environmental justice at the appropriate geographic scale.

Further, in addition to displaying data relevant to health, environmental, and social indicators, CalEnviroScreen calculates an environmental justice score for every census tract in the state, which allows the comparison of census tracts in terms of cumulative impacts instead of just one indicator at a time. The State of California uses the data and results displayed in CalEnviroScreen to inform the development and implementation of its environmental justice policy. The State of Michigan could look to California in terms of collecting relevant, state-specific data pertinent to health and environmental exposure, and using this data to calculate an environmental justice score for every census tract in Michigan.

Adapting best practices from MPCA and CalEPA to develop a Michigan-specific environmental justice screening tool is possible, as demonstrated by the Michigan-specific screening tool developed by this research team. EJScreen presented a starting point for accessible, usable, and relevant data. The research team used these data, along with data from the US Census Bureau and HUD, to calculate an environmental justice score for every census tract so that cumulative impacts could be analyzed and considered instead of considering impacts one indicator or permit at a time. The State could adopt and maintain this screening tool and develop it according to additional community input. The State could also move towards prioritizing the collection and management of additional relevant data. Interagency cooperation in Michigan would facilitate the collection and use of such data.

The development of a Michigan-specific environmental justice screening tool that displays cumulative impacts is desired by environmental justice leaders in the state. One of the recommendations of the Governor's Environmental Justice Work Group was to "Develop an environmental justice screening tool in Michigan and include cumulative impacts in decision making processes" (Environmental Justice Work Group 2018). The

group that proposed this recommendation consisted of representatives of the environmental, business, environmental justice, tribal, and academic communities, along with the State and local governments. Interview data from this research also indicated that leaders supported the development of such a tool.

It is crucial for the State to consider cumulative impacts of environmental exposures. According to interview participants, many Michigan residents experience exposure to multiple environmental harms at one time - air pollution, contaminated water, limited access to food, etc. One interviewee addressed the importance of cumulative impacts when they said, *“And each one of those industries gets treated like it’s operating in a vacuum when it’s getting its permit. And so that’s not how we live. We live the messy, cumulative total of all of that.”* It is essential that the State address cumulative impacts that residents encounter at one time and over the span of their lives, as each exposure comes with its own risks and impacts.

The tool should also incorporate community and public input to ensure the indicators are relevant to community members and that community members are able to access, use, and make sense of the data. One interview participant spoke to the importance of ensuring the data displayed resonates with residents’ experience when they said, *“I consider community input, and then see what the data has to say about it. Because the data is not as reliable as actually people, what people are dealing with.”* In comparison, every iteration of CalEnviroScreen has incorporated public comment, and several indicators have been added based on input from community members (Faust et al. 2017). One potential way to incorporate community input could be following the recommendation from the Environmental Justice Work Group to create an external advisory committee that includes community representatives (Environmental Justice Work Group 2018). Furthermore, the tool should be available in languages that are prevalent in the state, such as Spanish and Arabic, which are spoken by over 270,000 people and 111,000 people in Michigan, respectively (US Census Bureau 2015).

In addition to a screening tool, environmental justice leaders expressed a desire for a formalized reporting mechanism to communicate emerging environmental issues directly to the State. This desire is consistent with another recommendation from the Environmental Justice Work Group, which suggested the

establishment of a “petition process” that residents could utilize to communicate and seek action for emerging health and environmental issues in residents’ communities (Environmental Justice Work Group 2018). This reporting mechanism could be connected to or hosted on the same platform as the screening tool.

7.3 Policy Support

While there was clear support among interviewees for the development of an environmental justice screening tool, there also seemed to be agreement that a screening tool is not enough to advance environmental justice in the state. A tool would only be helpful in informing and advancing environmental justice if it was used to advise state-level policy that addressed the disproportionate impact of environmental harm and access to environmental goods that exists across the state. In comparison, both Minnesota and California use screening tools that are embedded within and supported by state-level policy. Michigan needs strong state-level environmental justice policy.

Based on qualitative data analysis, there are some environmental justice issues that are not easily captured by a screening tool, and policy must be created to address these components of residents’ experiences. There is not a clear indicator that can capture many of the barriers gleaned from qualitative data analysis, such as lack of funding, lack of time, or feeling ignored by the government. State-level policies might be able to address these barriers better than a screening tool could. Additionally, having clear legal processes to follow would relieve the need for community members to advocate for specific developments one by one or ad hoc, diminishing the burden currently placed on individuals and environmental justice organizations in terms of investment of resources including money, time, and effort. Clear procedures could also diminish uncertainty regarding steps to take in the event of environmental harm, with the potential of relieving the added stress that community members experience as a result of experiencing procedural injustices. There is also the potential for a tool to leave out relevant impacts based on inaccessibility or unavailability of data. Having strong policy to

protect Michigan communities from disproportionate environmental exposure would be significant in case a screening tool could not capture aspects of the experience.

A clear direction for future research is analyzing the political process in Michigan as compared to other states in terms of supporting and advancing environmental justice. Future research could examine policies in other states that use environmental justice screening tools, and analyze how screening tools and state-level policy can work together to support communities. Future research could also focus on the expansion of collection and dissemination of health, environmental, and social data that are relevant to environmental justice. There were several datasets used by other states in their screening tools that the research team was unable to find or access for Michigan.

Chapter 8. Conclusion

The state of Michigan has a long history of manufacturing and industrial activity that has contributed to both the economic development of the state as well as to a culture of strong grassroots movements advocating for environmental quality along with state residents' health and wellbeing. Additionally, there is a long history of correlation between environmental harms and low-income, minority, and indigenous communities. The state of environmental justice in Michigan today can be traced back to these historical factors that shaped the culture and identity of different factions of society in Michigan. Through this research, the team provided evidence that environmental injustice is prevalent in Michigan. However, this study also provides evidence that significant steps can be taken to address environmental inequities.

Essential steps to advancing environmental justice include the adoption, maintenance, and use of a screening tool that identifies communities at risk based on cumulative impacts. This Michigan-specific screening tool could incorporate community input, and could be used to develop policies that assure the equal distribution of environmental goods and harms. The tool could also be revised and improved through the years, as data collection practices change and as the needs of Michigan constituents evolve. Another essential step includes creating a reporting mechanism that allows members of these communities to communicate emerging environmental justice issues through a simple, accessible, yet formal process directly to the State. This mechanism should be accompanied by consistent action and follow-up to correct the issues reported.

There are several limitations to this study. In terms of data collection, interviews were only conducted with thirty environmental justice leaders in Michigan. These perspectives could be supplemented with interviews from additional leaders and community members, along with governmental and industry representatives, to gain a more nuanced perspective on social, environmental, and health issues. Quantitative data collection was weighted toward air quality indicators due to the differences in data availability between air and water quality. This weighting toward air quality could be addressed through the incorporation of more

water quality indicators, and indicators that capture additional environmental issues. Further, quantitative data analysis is limited by the observation that many risks and impacts described by interviewees are not included in the indicators used in spatial analysis, such as indoor air quality, sea level rise, pipeline leaks, increased heat events, or access to green space among others. The presence or absence of indicators and types of indicators can skew the results of spatial and statistical analysis, making it imperative that risks and impacts identified by community members in all parts of the state are included in the tool in order avoid any geographical misrepresentations. Another need that was emphasized by community members but was not incorporated in the tool was a self-reporting mechanism. Future work could focus on adding a geo-tagging function to the tool which would allow for spatial self-reporting of issues relevant to environmental justice. Additionally, regular updating of the tool's data on an annual (or otherwise appropriate) basis was not addressed by the team.

Finally, during the course of this study, the University of Washington's Department of Environmental & Occupational Health Sciences developed a spatial analysis tool modeled after CalEnviroScreen but specific to the state of Washington in collaboration with Front and Centered, a coalition of community organizations; the Washington State Department of Health; the Washington State Department of Ecology; and the Puget Sound Clean Air Agency. This Washington Environmental Health Disparities Map (<https://fortress.wa.gov/doh/wtn/WTNIBL/>) is one of the newest tools to emerge in environmental justice (University of Washington 2019a). The Washington State Department of Health hosts the tool, which was released after a two year process during which developers gathered input from community groups through eleven listening sessions (University of Washington 2019b). This report does not analyze Washington's approach and methodology, but it is worth noting that this tool is the latest development in state-level spatial analysis of environmental justice.

Additional research should be conducted to analyze how to better integrate policies and tools for the advancement of environmental justice in the state of Michigan. Researchers could examine the approaches of other states that have taken steps to integrate environmental justice considerations in their agencies' operations,

as well as examining any further guidance from the Environmental Protection Agency. Additionally, future studies could build off of this one, incorporating supplemental statistical and other forms of analyses to further characterize the state of environmental justice in Michigan. Such analyses could explore how specific indicators differ between the top twenty five and bottom seventy five percent of census tracts or how sensitive the scoring system is to changes in specific variables. These analyses could provide further nuance into this baseline assessment of environmental justice in the state.

In summary, this report provides a baseline of information about the state of environmental justice in Michigan that can be used to measure progress, or lack thereof, in the future. The report also provides different approaches to screen for environmental justice vulnerabilities, delineating the trade offs between the different approaches. In addition, based on the concerns of leaders interviewed for this project, and their emphasis on cumulative impacts and the intersection of environmental, socioeconomic, and health impacts, the team utilized a combined approach to create a Michigan-specific screening tool that could be adopted, revised based on community input and the availability of additional data, maintained, and utilized to screen for and address environmental injustice in the state.

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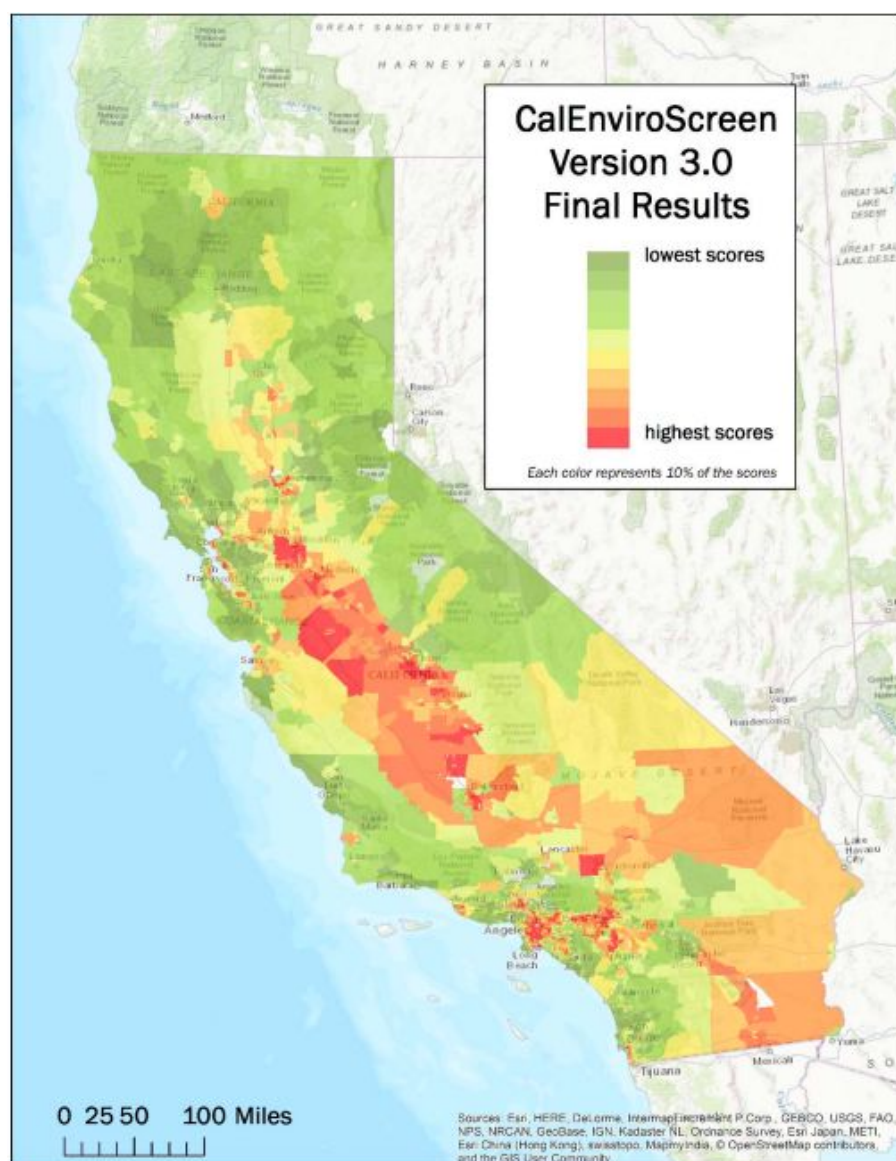
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Appendices

Appendix A: CalEnviroScreen Results



Appendix B: Interview Guide

Interviewer:

Good morning/afternoon Ms./Mr. _____, we are a group of University of Michigan students working with the Michigan Environmental Justice Coalition to assess the state of environmental justice in Michigan. In order to conduct this assessment, we will be reviewing what kind of data are currently being collected in the State of Michigan in comparison to other states that have comprehensive tools to conduct environmental justice screenings or assessments. We also want to make sure that the environmental justice issues that are important for the affected communities are incorporated into our assessment.

As someone involved in environmental justice issues, we would like to ask you some questions about the environmental justice issues taking place in the community you live in, work in, advocate for, or know about. Your input about current issues and the experiences of community members will help us to incorporate more complete information into our assessment, or to point out the limitations of the assessment and provide recommendations for future data collection practices.

The interview will take approximately 30 minutes to an hour. Participation in the study will be over after the interview. However, you may be contacted within six months of the interview for a follow-up.

If you do not feel comfortable answering any of the questions you can let us know and we will move on to other questions. You may also end the interview at any point, for any reason. The information we collect with this and other interviews will be used to assist the evaluation of environmental justice in Michigan.

The interview requires consenting to audio recording. The interviews will be digitally recorded using software on a digital audio recording device that will be used solely for this study. The digital audio recordings will be transcribed within 72 hours of the interview and then immediately destroyed. All recordings will have your unique identifying code on all documents and data files after signing consent on this document.

We will keep your information confidential by securely storing all physical and digital copies of study materials. All hard copies of study data will be converted to digital PDF's, protected by password and encryption, only accessible to the researchers and our faculty advisor. The code key will be stored as a password-protected, encrypted digital file on my password-protected, personal computer.

Only information that is void of all direct identifiers will be shared, this may include direct quotes from this interview. Please do not provide personal information that could be used to identify you, or a relative, during this interview. This may include landmarks, names, and other personally specific information. While all attempts will be made to remove such information from the transcribed files, there is a risk that your identity could be determined from your responses. On a related note, please try to refrain from stating information that could be used to identify friends, family members, or other third parties as this puts those individuals at risk of breaching confidentiality.

Raw digital copies of audio recordings will never be sent to outside researchers. The results of this research may be published or used for teaching or other educational outlets, like academic presentations. Again, identifiable information will not be used for these purposes. If you would like a copy of the finished research, please let us know and this can be made available to you at no cost.

We would also like to store some of the information from this study for future use related to environmental justice in the State of Michigan. The information to be stored for future use includes only the transcribed audio, or manually-typed records from study interviews. This information will be labeled with a code and will not include your name or direct identifiers. This information will be stored in a password-protected or locked file.

Before we move on, do you have any questions?

After answering questions, if applicable

Now we are ready to ask for your consent to participate in this interview.

We will turn on the audio recording device to record your response to consent in participation of this study. Is this okay?

Turn on audio recording device after receiving confirmatory response

If you would like to participate in this study, are over the age of 18 years old, and understand all the information that has been explained to you today, will you please state your name, today's date, and the following sentence:

"I understand the information that has been presented to me and I consent to participating in this study."

record participant

We appreciate your participation and patience with this important process very much. Let's move on to the interview.

Ice breaker

1. How did you become involved in Environmental Justice?
2. Can you tell me if you currently live or work in a community in Michigan that is affected by environmental justice issues?

If participant lives or works in an affected community:

Getting to know/ gaining trust:

1. How long have you lived/worked in your community?

2. Tell me about family or friends that live/work in this community?
3. Besides residing/working here, tell me about other things that you do or experience in your community?

Positive aspects of the community:

4. Describe some things you like about your community?
5. What about things in your community that others seem to like?

Challenges in the community:

6. What are some of things you wish were different in your community?
 - a. Walk me through your most recent challenge?
7. Do you know of other people that face the same or similar challenges?

Impacts of the challenges:

8. What are some ways these challenges affect your day to day life?
9. What resources are you aware of that could help you or others with these issues?

Advocacy tools:

10. Tell me about any information or tools that you have used to advocate for your community.
 - a. What are they?
 - b. How have you used them?
11. Are you aware of and familiar with the 33 recommendations of the Governor's EJ Work Group Report released this past March? Yes or no?
 - a. One of the recommendations from the report was to:

"2. Develop an environmental justice screening tool in Michigan and include cumulative impacts in decision making processes"

This tool would be similar to EPA's EJScreen and California's CalEnviroScreen that gather information about environmental and social indicators that may show which communities might be at risk of disproportionate environmental impacts.

What are your thoughts on this recommendation?

12. Have you used a tool like EPA's EJScreen to find out about environmental issues in your community?
 - a. If yes:
 - i. How recently? How frequently? *If not recently or frequently go to b*

- ii. Tell me about a recent time when you used it. What impacts did it help you identify?
 - iii. Earlier in the interview you mentioned some of the challenges you experience in your community. How well do you think the tool is able to capture those challenges?
 - iv. If you worked for the EPA and had the power to change this tool, what would you change/add/subtract?
 - b. If no, not recently, or not frequently:
 - i. Are there any reasons that have prevented you to use this tool?
13. Is there a way for community members to report an issue related to environmental justice?
- a. To whom would they report?
 - b. What are your thoughts on this process?
14. Are there any issues that you think are important for our study that I have not asked you about?
15. Can you tell me if you know of other EJ advocates that you think could contribute to our study?
- a. If yes. Can you provide their names and contact information?

If participant does not live or work in an affected community, but is a professional, scholar or community activists involved in either capacity in Environmental Justice in Michigan.

Getting to know/ gaining trust:

- 1. How long have you been involved in environmental justice?
- 2. Tell me about some common or salient issues people experience in EJ communities in Michigan?

Positive aspects of EJ communities or the State:

- 3. What is going well in terms of environmental justice in Michigan?
 - a. Have there been any recent wins?

EJ Challenges:

- 4. What are some of the challenges Michigan residents face because of living/working in communities affected by environmental justice issues?
 - a. Walk me through a recent challenge that you may have helped with or learned about?
- 5. Do you know of other communities or areas in Michigan that face the same or similar challenges?

Impacts of the challenges:

- 6. What are some ways these challenges affect the day to day lives of residents of affected communities?
- 7. What resources are you aware of that could help Michigan residents with these challenges?

Advocacy tools:

8. Tell me about any information or tools that you have used to advocate for those communities.
 - a. What are they?
 - b. How have you used them?
9. Are you aware of and familiar with the 33 recommendations of the Governor's EJ Work Group Report released this past March? Yes or no?

- a. One of the recommendations from the report was to:

"2. Develop an environmental justice screening tool in Michigan and include cumulative impacts in decision making processes"

This tool would be similar to EPA's EJScreen and California's CalEnviroScreen that gather information about environmental and social indicators that may show which communities might be at risk of disproportionate environmental impacts.

What are your thoughts on this recommendation?

10. Have you used a tool like EPA's EJScreen to find out about environmental issues in those communities?
 - a. If yes:
 - i. How recently? How frequently? *If not recently or frequently go to b*
 - ii. Tell me about a recent time when you used it. What impacts did it help you identify?
 - iii. Earlier in the interview you mentioned some of the challenges people experience in EJ communities. How well do you think the tool is able to capture those challenges?
 - iv. If you worked for the EPA and had the power to change this tool, what would you change/add/subtract?
 - b. If no, not recently, or not frequently:
 - i. Are there any reasons that have prevented you to use this tool?
11. Is there a way for community members to report an issue related to environmental justice?
 - a. To whom would they report?
 - b. What are your thoughts on this process?
12. Are there any issues that you think are important for our study that I have not asked you about?
13. Can you tell me if you know of other EJ advocates that you think could contribute to our study?
 - a. If yes. Can you provide their names and contact information?

Appendix C: Word Frequency Chart

Word	Length	Count	Weighted Percentage	Similar Words
people	6	1011	1.75%	people, peoples
think	5	795	1.37%	think, thinking, thinks
community	9	730	1.26%	communities, communities', community
knowing	7	636	1.10%	know, knowing, knows
just	4	593	1.02%	just
works	5	515	0.89%	work, worked, working, works
environmentally	15	493	0.85%	environmental, environmentalism, environmentally
get	3	459	0.79%	get, gets, getting
ones	4	458	0.79%	one, ones
lot	3	455	0.79%	lot, lots
issues	6	445	0.77%	issue, issued, issues
going	5	369	0.64%	going
wells	5	365	0.63%	well, wells
justice	7	363	0.63%	justice, justices
waters	6	337	0.58%	water, watered, waters

detroit	7	296	0.51%	detroit, detroiter, detroiters
now	3	289	0.50%	now
coming	6	282	0.49%	come, comes, coming
means	5	261	0.45%	mean, meaning, means
right	5	256	0.44%	right, rightly, rights
city	4	254	0.44%	cities, city
states	6	252	0.44%	state, states, stating
michigan	8	251	0.43%	michigan
using	5	248	0.43%	use, used, useful, usefulness, uses, using
times	5	239	0.41%	time, times, timing
want	4	237	0.41%	want, wanted, wanting, wants
look	4	234	0.40%	look, looked, looking, looks
living	6	231	0.40%	live, lived, lives, living
trying	6	230	0.40%	tri, tried, try, trying
talk	4	230	0.40%	talk, talked, talking, talks
needs	5	220	0.38%	need, needed, needs
seeing	6	220	0.38%	see, seeing, sees
kinds	5	217	0.37%	kind, kinds

health	6	210	0.36%	health
ways	4	209	0.36%	way, ways
years	5	206	0.36%	year, yearly, years
making	6	191	0.33%	make, makes, making
impact	6	190	0.33%	impact, impacted, impactful, impacting, impacts
call	4	187	0.32%	call, called, calling, calls
thing	5	187	0.32%	thing
area	4	186	0.32%	area, areas
parts	5	183	0.32%	part, partly, parts
organizing	10	182	0.31%	organ, organic, organics, organization, organizations, organize, organized, organizer, organizers, organizing
good	4	172	0.30%	good
tools	5	171	0.30%	tool, tools
happening	9	168	0.29%	happen, happened, happening, happenings, happens
group	5	168	0.29%	group, groups
helps	5	167	0.29%	help, helped, helpful, helping, helps

air	3	164	0.28%	air
information	11	156	0.27%	inform, informal, informally, information, informational, informed, informing
differently	11	154	0.27%	differ, difference, differences, different, differently, differing
around	6	149	0.26%	around
still	5	136	0.23%	still
taking	6	136	0.23%	take, takes, taking
public	6	134	0.23%	public, publication, publications, publicity, publicly
started	7	132	0.23%	start, started, starting, starts
problem	7	131	0.23%	problem, problems
level	5	129	0.22%	level, levels
pollution	9	128	0.22%	pollutant, pollutants, polluted, polluters, polluting, pollution
food	4	128	0.22%	food, foods
neighborhood	12	124	0.21%	neighborhood, neighborhoods
flint	5	123	0.21%	flint

done	4	117	0.20%	done
industry	8	115	0.20%	industrial, industrialized, industries, industry
data	4	115	0.20%	data
meetings	8	114	0.20%	meet, meeting, meetings, meets
able	4	114	0.20%	able
places	6	113	0.20%	place, placed, places, placing
always	6	113	0.20%	always
quality	7	113	0.20%	quality
change	6	113	0.20%	change, changed, changes, changing
permit	6	111	0.19%	permit, permits, permitted, permitting
resources	9	109	0.19%	resource, resources
understand	10	106	0.18%	understand, understandable, understanding, understands
terms	5	106	0.18%	term, terms
involves	8	105	0.18%	involve, involved, involvement, involves, involving
accessible	10	103	0.18%	'access', access, accessed, accessibility, accessible

big	3	103	0.18%	big
dearborn	8	103	0.18%	dearborn
day	3	99	0.17%	day, days
certain	7	98	0.17%	certain, certainly
challenge	9	97	0.17%	challenge, challenged, challenges, challenging
feel	4	96	0.17%	feel, feeling, feelings, feels
lead	4	96	0.17%	lead, leading, leads
money	5	96	0.17%	money
question	8	96	0.17%	question, questionable, questioning, questions
report	6	96	0.17%	report, reportable, reported, reporter, reporting, reports
school	6	96	0.17%	school, schools
move	4	92	0.16%	move, moved, moving
sort	4	91	0.16%	sort, sorts
funds	5	90	0.16%	fund, funded, funding, funds
homes	5	89	0.15%	home, homes
another	7	87	0.15%	another
greatly	7	87	0.15%	great, greatly
river	5	86	0.15%	river, rivers

new	3	84	0.15%	new
housing	7	84	0.15%	house, housed, houses, housing
concerns	8	83	0.14%	concern, concerned, concerns
hear	4	82	0.14%	hear, hearing, hearings, hears
person	6	82	0.14%	person, personal, personally

Appendix D: Indicator Comparison Matrix

			Measure of environmental exposure					
			Discrete count of environmental sites					
			Not present in either capacity					
	US EPA's EJ Screen		Cal EPA's CalEnviroScreen		Minnesota PCA's			
Indicator	Metric	Source	Metric	Source	Metric	Story Map Source	What's in My Neighborhood Metric Source	
Environmental Indicators								
Air Quality							Permits for facilities that emit air pollutants	MPCA
NATA air toxics cancer risks	Lifetime cancer risk from inhalation of air toxics	EPA NATA (2011)						
NATA respiratory hazard index	Ratio of exposure concentration to health-based reference concentration	EPA NATA (2011)						
Diesel PM								
NATA diesel PM	Diesel particulate matter level in air (micrograms per cubed meter)	EPA NATA 2011						
CARB diesel PM			Spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2012 summer day in July (kg/day)	California Air Resources Board (CARB) San Diego Association of Governments (SANDAG) (2012)				
Particulate matter								
PM 2.5	Annual average PM2.5 levels in air obtained through a fusion of model and monitor data (micrograms per cubed meter)	EPA CARB (2014)	Annual mean concentration of PM2.5 (average of quarterly means, µg/m3), over three years (2012 to 2014)	Air Monitoring Network, California Air Resources Board (CARB) (wide network of air monitoring station) (2012 to 2014) Other potential sources: http://www.arb.ca.gov/aqmis2/aqmis2.php http://www.epa.gov/airquality/particledepolution/				
PM 10								
Ozone	Seasonal average of daily maximum 8-hour concentration in air obtained through fusion of model and monitor data (ppb)	EPA CARB (2013)	Mean of summer months (May-October) of the daily maximum 8-hour ozone concentration (ppm), averaged over three years (2012 to 2014)	Air Monitoring Network, California Air Resources Board (CARB) (wide network of air monitoring station) (2012 to 2014) Other potential sources: EPA Air Now https://www.airnow.gov http://www.arb.ca.gov/aqmis2/aqmis2.php http://www.epa.gov/airquality/ozoneapo http://www.niahs.nih.gov/healthtopics/agen15/ozone/				
Traffic proximity and volume	Count of vehicles at major roads with 500 meters, divided by distance in meters (calculated from 2014 US DOT traffic data)	US DOT (2014)	Traffic density – Sum of traffic volumes adjusted by road segment length (vehicle-kilometers per hour) divided by total road length (kilometers) within 150 meters of the census tract boundary (2013)	California Environmental Health Tracking Program (CEHTP), California Department of Public Health US Department of Transportation and US Customs and Border Protection San Diego Association of Governments (SANDAG) (2013)			Permits for facilities discharging water pollution	MPCA
Water Quality								

	Non-Potable Water Quality			Summed number of pollutants across all water bodies designated as impaired within the area (2012)	353(d) List of Impaired Water Bodies, State Water Resources Control Board (SWRCB) (2012) http://www.waterboards.ca.gov/swrcb2/water_issues/programs/TMDLs/353dlist.shtml		Permits for facilities discharging water pollution	MPCA
	Surface Water Bodies						Permits for facilities discharging water pollution	MPCA
	Groundwater Sources						Permits for facilities discharging water pollution	MPCA
	Drinking Water Quality			Drinking water contaminant index for selected contaminants	Drinking Water Systems Geographic Reporting Tool, California Environmental Health Tracking Program, California Department of Public Health (CDPH) http://cehtp.org/page/water/water_system_map_viewer Public Water System Location Data Permitting/Inspection/Compliance/Monitoring/Enforcement (PICME) database, California Department of Public Health Safe Drinking Water Information System, US Environmental Protection Agency http://water.epa.gov/dwtech/catalistdata/bases/drinkingwater/index.cfm Water Quality Monitoring Database, CDPH http://www.cdph.ca.gov/ncdc/ncdrinkingwater/Pages/EDTlibrary.aspx Domestic Well Project, Groundwater Ambient Monitoring and Assessment (GAMA) Program, State Water Resources Control Board http://www.waterboards.ca.gov/water_issues/programs/gama/domestic_well.shtml Priority Basin Project, GAMA Program, State Water Resources Control Board and US Geological Survey http://www.waterboards.ca.gov/water_issues/programs/gama/priority_basin_projects.shtml (2005-2013)		Information on Community Water Systems	MPCA
	Wastewater Discharges Indicator	toxicity-weighted stream concentrations at stream segments within 500 meters, divided by distance in km (calculated from RSEI modeled toxicity-weighted stream concentrations)	EPA (2017)				Permits for facilities discharging water pollution	MPCA
	Pollution						Permits for polluting facilities and those facilities that treat, store, or dispose of hazardous waste	MPCA
	Sub-Surface Sewage Treatment Systems						Permitting for SSWTs (septic systems) which must be registered with MPCA	MPCA

Hazardous Waste Facilities							Permits for hazardous waste facilities (including RCRA)	MPCA
	Proximity to Risk Management Plan (RMP) sites	Count of RMP facilities (facilities with a chemical accident management plan) within 5 km (or nearest one beyond 5 km), each divided by distance in km (calculated from EPA RMP database)	EPA (2017)					
	Proximity to Hazardous Waste Facilities	Count of TSD's or LQG's within 5 km (or nearest beyond 5 km), each divided by distance in KM (calculated from EPA RCRA into database)	EPA (2017)	Sum of weighted permitted hazardous waste facilities and hazardous waste generators within each census tract. (Permitted hazardous waste facilities was downloaded December 2016. Hazardous waste data is from 2012-2014.)	EnviroStor Hazardous Waste Facilities Database and Hazardous Waste Tracking System, Department of Toxic Substances Control (DTSC) http://www.envirostor.dtsc.ca.gov/publicdata_download.asp http://hwtb.dtscc.ca.gov/ (Permitted hazardous waste facilities was downloaded December 2016. Hazardous waste data is from 2012-2014.)		Sites that have permits for TSD's	MPCA
	Proximity to National Priorities List (NPL) sites	Count of proposed and listed NPL sites (Superfund, National Priorities List) within 5 km (or nearest beyond 5 km), each divided by distance in km (calculated from EPA CERCLIS database)	EPA (2017)				Information related to clean-up and investigation sites, including NPL sites	MPCA/EPA
	Lead point indicator	Percent of housing units built pre-1960 (calculated based on 2015 Census data)	ACS (2011-2015)					
	Solid waste sites and facilities			Sum of weighted solid waste sites and facilities (as of December 2016).	Solid Waste Information System (SWIS) and Closed, Illegal, and Abandoned (CIA) Disposal Sites Program, California Department of Resources Recycling and Recovery, CalRecycle Hazardous Waste Tracking System, Department of Toxic Substances Control (DTSC) http://calrecycle.ca.gov/SWFacilities/Directory/ http://www.calrecycle.ca.gov/SWFacilities/CIA/ http://hwtb.dtscc.ca.gov/ (2016)		Permitting for facilities that process solid wastes	MPCA
	Feedlots						Presence of a feedlot (point-level data) - sites that meet criteria for MPCA registration (10 animals near shore, more than 50 animals inland).	Minnesota Department Agriculture
	Use of certain high-hazard high-volatility pesticides			Total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production agriculture per square mile, averaged over three years (2012 to 2014).	Pesticide Use Reporting, California Department of Pesticide Regulation (DPR) http://www.DPR.ca.gov/docs/pun/pumain.htm (2012 to 2014)			

				Risk Screening Environmental Indicators (RSEI) US Environmental Protection Agency (US EPA) Toxic Release Inventory (TRI) Mexico Registry of Emissions and Pollutant Transfer (RETG) http://www.epa.gov/epptri/tri/publi/tri_methodology_v2.3.1.pdf http://www.epa.gov/epptri/tri/publi/tri_users_manual_v2.3.1.pdf http://www.epa.gov/tri/index.htm http://www.epa.gov/epptri/tri/publi/technical_appendix_a_toxicity_v2.3.1.pdf http://www.semamat.gob.mx/temas/tema-ambiental/ciudad-del-aire/registro-de-emisiones-y-transferencia-de-contaminantes-retg-(2011-2013)	Permitting information for facilities that release toxic substances, via water or air, as required by MPCA.	MPCA
Toxic releases from facilities			Sum of weighted scores for sites within each census tract. (Data downloaded December 2016) The nature and the magnitude of the threat and burden posed by sites maintained in GeoTracker vary significantly by site type (e.g., leaking underground storage tank or cleanup site) and status (e.g., Completed Case Closed or Active Clean up). The Indicator takes into account information about the type of site, its status, and its proximity to populated census blocks.	GeoTracker Database, State Water Resources Control Board (SWRCB) http://geotracker.waterboards.ca.gov/ (2016)	Information on permitted sites, such as underground tanks, that are known to be leaking or have leaked in the past.	MCPA
Groundwater threats from leaking underground storage sites and cleanups			Sum of weighted sites within each census tract. (Data downloaded December 2016) Since the nature and the magnitude of the threat and burden posed by hazardous substances vary among the different types of sites as well as the site status, the indicator takes both into account. Weights were also adjusted based on proximity to populated census blocks.	EnviroStor Cleanup Sites Database, Department of Toxic Substances Control (DTSC) http://www.envirostor.dtsc.ca.gov/public/ US Environmental Protection Agency Region 9 Region 9 NPL Sites (Superfund Sites) Polygons https://wq.epa.gov/cptrahpl/ (2016)	Clean-up sites, including brownfields, are included in MPCA's tool to show where such activity is occurring.	MPCA
Toxic cleanup sites ("brownfields")						
Socio-economic Indicators						
Less than high school education	Number or percent of people age 25 or older in a block group whose education is short of a high school diploma	ACS (2011-2015)	Percent of the population over age 25 with less than a high school education (5-year estimate, 2011-2015)	American Community Survey US Census Bureau http://www.census.gov/acs/www/!//factfinder2.census.gov/ (2011-2015)		
Income			Percent of the population living below two times the federal poverty level (5-year estimate, 2011-2015)	American Community Survey US Census Bureau http://www.census.gov/acs/www/!//factfinder2.census.gov/ (2011-2015)	At least 40% of people reported income less than 165% of the federal poverty level	US Census - ACS
Proximity						

	Housing Burdened Low Income Households	Number or percent of a block group's population in households where the household income is less than or equal to twice the federal poverty level	ACS (2011-2015)	Housing Burdened Low Income Households. Percent of households in a census tract that are both low income (making less than 80% of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50% of their income to housing costs). (5-year estimates, 2009-2013)	Housing and Urban Development Comprehensive Housing Affordability Strategy American Community Survey US Census Bureau https://www.huduser.gov/portal/datasets/cps.html#2006-2013	At least 42% of people reported income less than 185% of the federal poverty level	US Census - ACS
	Low-income Employment			Percent of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2011-2015)	American Community Survey US Census Bureau http://www.census.gov/acs/www/http://factfinder2.census.gov/ (2011-2015)		
	Unemployment Minority	Number or percent of individuals in a block group who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino	ACS (2011-2015)			50% or more people of color	US Census - ACS
	Race	Number or percent of individuals in a block group who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino	ACS (2011-2015)			50% or more people of color	US Census - ACS
	Ethnicity					Federally-recognized tribal communities	US Census
	Tribal Status						
	Language	Number or percent of people in a block group living in a household in which all members age 14 years and over speak a non-English language and also speak English less than "very well"	ACS (2011-2015)	Percent limited English-speaking households, (2011-2015)	American Community Survey US Census Bureau http://www.census.gov/acs/www/http://factfinder2.census.gov/ (2011-2015)		
	Linguistic Isolation					Top three non-English languages spoken in a given environmental justice area of concern	Census Data (ACS)
	Languages spoken						
	Age	Number or percent of people in a block group under the age of 5	ACS (2011-2015)				
	Individuals under 5	Number or percent of people in a block group over the age of 64	ACS (2011-2015)				
	Individuals over age 64						

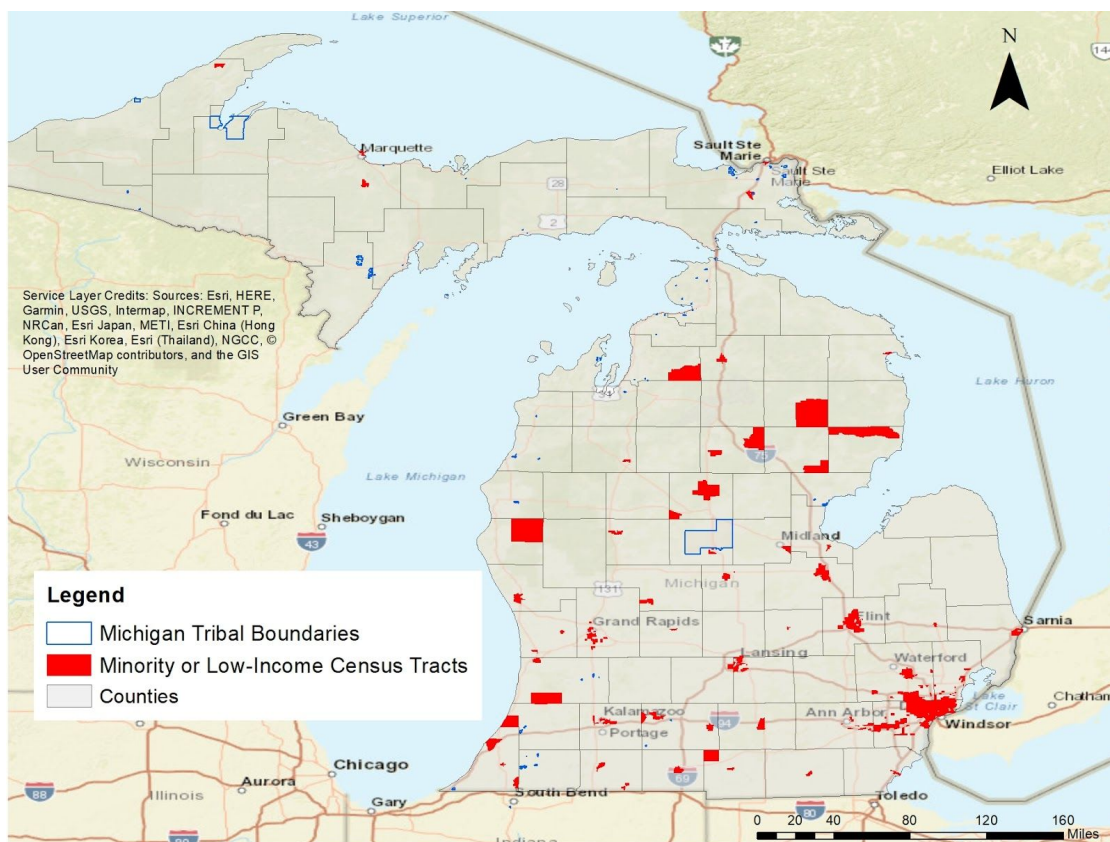
Health Indicators

Asthma emergency department visits	California Office of Statewide Health Planning and Development (OSHPD) California Environmental Health Tracking Program (CEHTP) Spatially modeled, age-adjusted rate of emergency department (ED) visits for asthma per 10,000 (averaged over 2011-2013). California Department of Public Health http://www.oshpd.ca.gov/HID/Products/Eme/DeptData/ http://www.cdph.org/page/asthma (2011-2013) California Office of Statewide Health Planning and Development (OSHPD) California Environmental Health Tracking Program (CEHTP) Environmental Health Investigations Branch, California Department of Public Health http://www.oshpd.ca.gov/HID/Products/Eme/DeptData/ http://www.cdph.org/page/heart_attack/
Cardiovascular disease	California Department of Public Health (CDPH) http://www.cdph.ca.gov/data/dataresource/s/requests/Pages/BirthandFatalDeaths.aspx (2006-2012)
Low birth-weight infants	

Appendix E: Minnesota Pollution Control Agency's Methodology Applied to Michigan Census Tracts

This map shows Michigan census tracts, which would be identified as “areas of concern for environmental justice” when applying the MPCA methodology of meeting at least one of the following criteria:

- *Percent of non-white population is at least 50%.*
- *“More than 40% of the households have a household income of less than 185% of the federal poverty level (FPL).”*
- *If the facility is within the boundaries of a “tribal community” (MPCA 2015).*



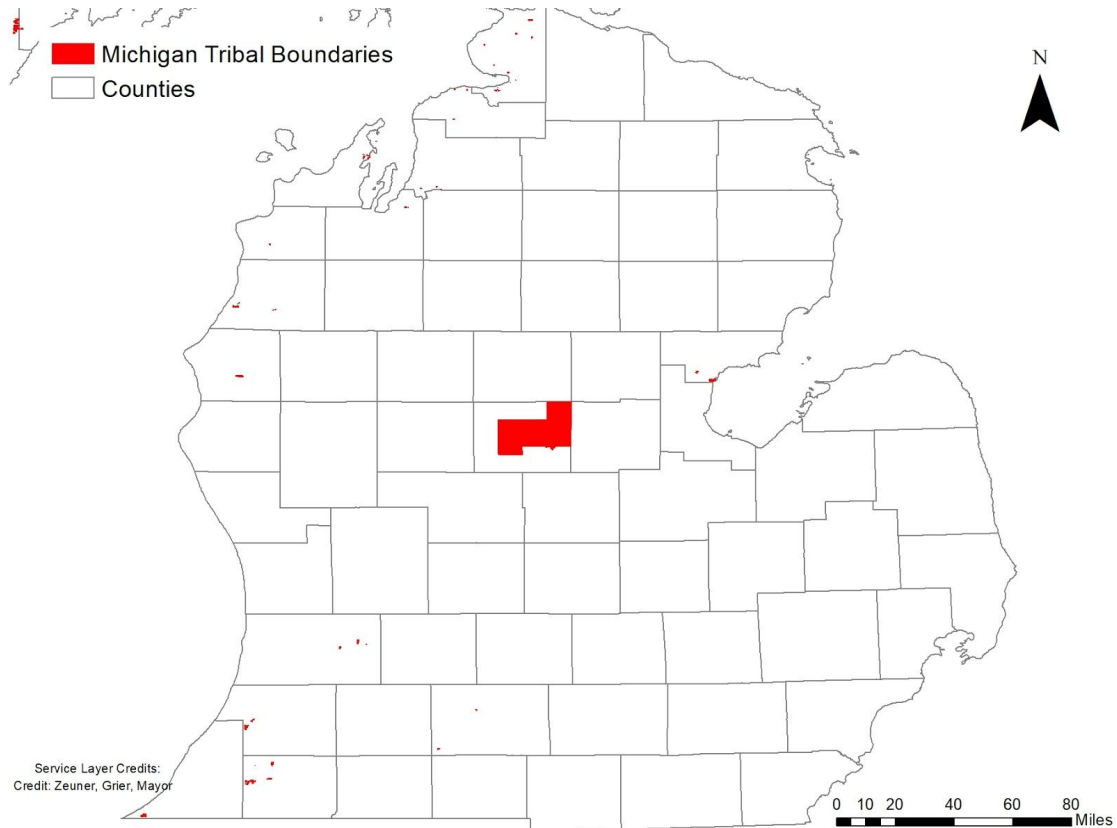
Appendix F: Comparing MPCA and CalEPA Methodologies

This map shows Michigan census tracts which would NOT be identified as “areas of concern for environmental justice” when applying the MPCA methodology but that ARE included in the top quartile of census tracts as ranked by an environmental justice score (calculated using CalEPA’s methodology with race and ethnicity data).

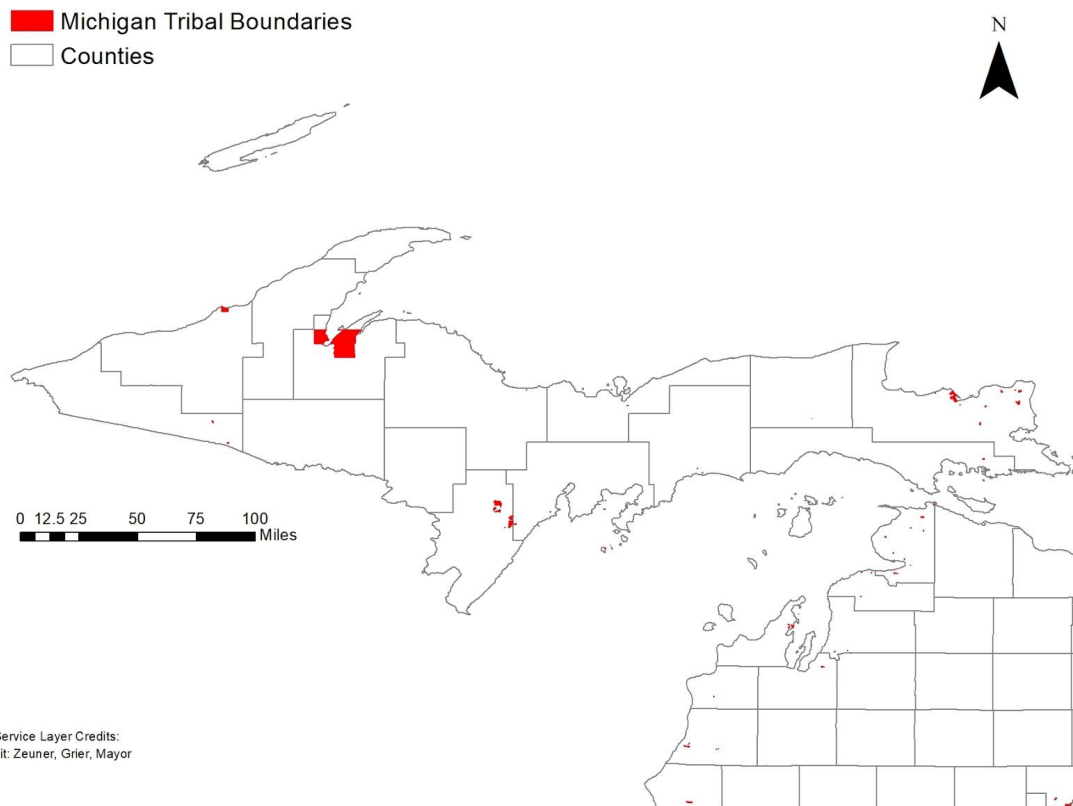


Appendix G: Tribal Areas within Michigan

This map shows the tribal areas throughout the Lower Peninsula of Michigan as defined by “federally recognized American Indian reservations, off-reservation trust land areas, and state-recognized American Indian reservations” (US Census Bureau 2019).



This map shows the tribal areas throughout the Upper Peninsula of Michigan as defined by “federally recognized American Indian reservations, off-reservation trust land areas, and state-recognized American Indian reservations” (US Census Bureau 2019).

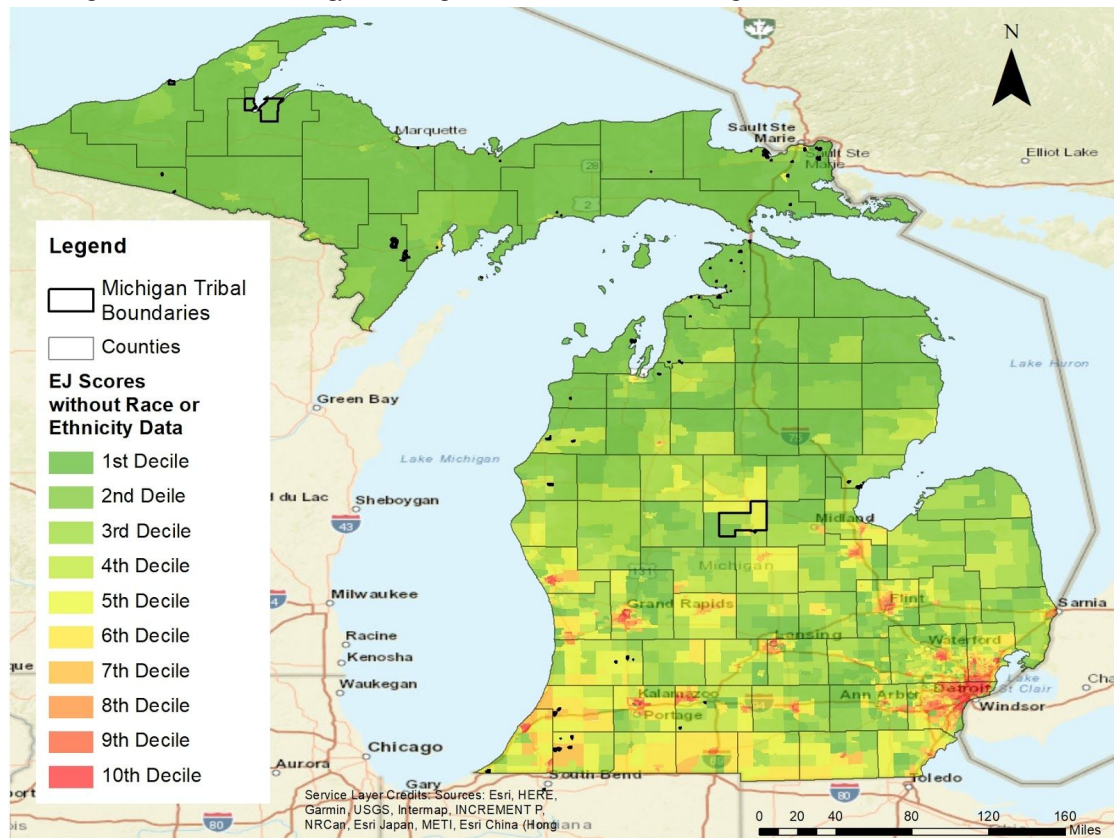


This table shows the thirteen tribal communities represented in the analysis based on data from the US Census Bureau. Area in square kilometers as well as county(ies) location is shown.

Tribal Name	Area (sq. km)	Counties
Huron Potawatomi	843.67	Calhoun
Little Traverse Bay	4,835.48	Charlevoix, Cheboygan, Emmet
Hannahville	23,675.19	Delta, Menominee
Lac Vieux Desert	1,084.32	Gogebic
L'Anse	238,227.45	Baraga
Isabella	564,779.59	Isabella
Pokagon	13,822.13	Berrien, Cass, Van Buren
Sault Ste. Marie	5,078.77	Alger, Chippewa, Mackinac, Schoolcraft
Little River	4,608.16	Manistee, Mason
Bay Mills	14,254.16	Chippewa
Ontonagon	9,679.64	Ontonagon
Match-e-be-nash-she-wish Band of Pottawatomi	2,299.53	Allegan
Grand Traverse	3,358.20	Antrim, Benzie, Charlevoix, Grand Traverse, Leelanau

Appendix H: California's CalEPA Methodology Applied to Michigan

Statewide map showing Michigan census tracts ranked according to CalEPA's methodology (without racial or ethnic data). Note that the map displayed in Figure 14 in Chapter 6 shows Michigan census tracts ranked according to CalEPA's methodology including racial and ethnic data, along with tribal boundaries.



Appendix I: List of Top 25% Michigan Census Tracts Ranked by Environmental Justice Score

Rank	Tract	EJ Score	Percentile	County	Rank	Tract	EJ Score	Percentile	County
1	0039	93.994	99.9%	KENT	51	5163	78.362	98.1%	WAYNE
2	0002	91.947	99.9%	KALAMAZOO	52	5741	78.326	98.1%	WAYNE
3	0003	90.173	99.9%	KALAMAZOO	53	5062	78.265	98.1%	WAYNE
4	0038	89.501	99.8%	KENT	54	5233	78.264	98.0%	WAYNE
5	0040	87.740	99.8%	KENT	55	5225	77.992	98.0%	WAYNE
6	0036	87.633	99.8%	KENT	56	5204	77.974	97.9%	WAYNE
7	0026	87.428	99.7%	KENT	57	5521	77.874	97.9%	WAYNE
8	5061	87.208	99.7%	WAYNE	58	5333	77.874	97.9%	WAYNE
9	5055	86.924	99.7%	WAYNE	59	5044	77.795	97.8%	WAYNE
10	5162	86.695	99.6%	WAYNE	60	0031	77.774	97.8%	KENT
11	0028	86.465	99.6%	KENT	61	2683	77.735	97.8%	MACOMB
12	5051	85.868	99.5%	WAYNE	62	0019	77.707	97.7%	KENT
13	5189	85.295	99.5%	WAYNE	63	5081	77.697	97.7%	WAYNE
14	5050	84.768	99.5%	WAYNE	64	5255	77.574	97.7%	WAYNE
15	0001	84.763	99.4%	KALAMAZOO	65	5075	77.407	97.6%	WAYNE
16	5032	84.749	99.4%	WAYNE	66	5065	77.389	97.6%	WAYNE
17	5238	84.334	99.4%	WAYNE	67	5048	77.253	97.5%	WAYNE
18	0037	84.157	99.3%	KENT	68	5004	77.119	97.5%	WAYNE
19	2638	83.977	99.3%	MACOMB	69	5119	77.059	97.5%	WAYNE
20	5159	83.727	99.3%	WAYNE	70	5121	76.981	97.4%	WAYNE
21	5047	83.645	99.2%	WAYNE	71	5740	76.952	97.4%	WAYNE
22	5110	83.328	99.2%	WAYNE	72	0005	76.840	97.4%	MUSKEGON
23	0009	83.244	99.1%	KALAMAZOO	73	5107	76.819	97.3%	WAYNE
24	5054	83.144	99.1%	WAYNE	74	5273	76.789	97.3%	WAYNE
25	5250	82.491	99.1%	WAYNE	75	5240	76.688	97.2%	WAYNE
26	5142	81.079	99.0%	WAYNE	76	5114	76.680	97.2%	WAYNE
27	5243	80.758	99.0%	WAYNE	77	5795	76.588	97.2%	WAYNE
28	2639	80.742	99.0%	MACOMB	78	5220	76.494	97.1%	WAYNE
29	5245	80.624	98.9%	WAYNE	79	5105	76.489	97.1%	WAYNE
30	5049	80.590	98.9%	WAYNE	80	0032	76.444	97.1%	KENT
31	0002	80.489	98.9%	KALAMAZOO	81	5068	76.367	97.0%	WAYNE
32	5334	80.483	98.8%	WAYNE	82	5272	76.216	97.0%	WAYNE
33	0010	80.275	98.8%	KALAMAZOO	83	5345	76.198	97.0%	WAYNE
34	5035	80.177	98.7%	WAYNE	84	5324	76.198	96.9%	WAYNE
35	5033	80.089	98.7%	WAYNE	85	5063	76.182	96.9%	WAYNE
36	5234	80.082	98.7%	WAYNE	86	5080	76.052	96.8%	WAYNE
37	2640	79.966	98.6%	MACOMB	87	5249	76.023	96.8%	WAYNE
38	5232	79.916	98.6%	WAYNE	88	5104	76.006	96.8%	WAYNE
39	0005	79.890	98.6%	BERRIEN	89	5136	75.919	96.7%	WAYNE
40	5052	79.799	98.5%	WAYNE	90	0020	75.751	96.7%	KENT
41	5224	79.742	98.5%	WAYNE	91	5036	75.596	96.7%	WAYNE
42	5161	79.581	98.5%	WAYNE	92	5066	75.444	96.6%	WAYNE
43	5248	79.349	98.4%	WAYNE	93	5173	75.389	96.6%	WAYNE
44	5067	79.150	98.4%	WAYNE	94	5160	75.347	96.6%	WAYNE
45	5258	79.055	98.3%	WAYNE	95	5031	75.343	96.5%	WAYNE
46	5143	78.974	98.3%	WAYNE	96	5222	75.181	96.5%	WAYNE
47	5145	78.911	98.3%	WAYNE	97	5188	75.082	96.4%	WAYNE
48	5039	78.901	98.2%	WAYNE	98	0135	74.991	96.4%	KENT
49	5247	78.535	98.2%	WAYNE	99	5219	74.921	96.4%	WAYNE
50	5793	78.407	98.2%	WAYNE	100	5112	74.794	96.3%	WAYNE

Rank	Tract	EJ Score	Percentile	County	Rank	Tract	EJ Score	Percentile	County
101	0068	74.779	96.3%	INGHAM	151	5069	72.656	94.5%	WAYNE
102	1422	74.719	96.3%	OAKLAND	152	1417	72.622	94.4%	OAKLAND
103	2632	74.686	96.2%	MACOMB	153	5331	72.558	94.4%	WAYNE
104	5223	74.587	96.2%	WAYNE	154	5003	72.465	94.4%	WAYNE
105	0013	74.570	96.2%	KENT	155	0043	72.401	94.3%	MUSKEGON
106	5254	74.495	96.1%	WAYNE	156	5261	72.384	94.3%	WAYNE
107	5242	74.420	96.1%	WAYNE	157	5203	72.317	94.3%	WAYNE
108	5530	74.409	96.0%	WAYNE	158	0006	72.280	94.2%	MUSKEGON
109	5791	74.373	96.0%	WAYNE	159	5221	72.209	94.2%	WAYNE
110	0012	74.354	96.0%	MUSKEGON	160	5265	72.130	94.1%	WAYNE
111	5335	74.352	95.9%	WAYNE	161	5322	72.077	94.1%	WAYNE
112	5528	74.324	95.9%	WAYNE	162	5330	72.007	94.1%	WAYNE
113	0027	74.310	95.9%	KENT	163	5256	71.991	94.0%	WAYNE
114	0004	74.293	95.8%	BERRIEN	164	5798	71.974	94.0%	WAYNE
115	0042	74.260	95.8%	MUSKEGON	165	0018	71.951	94.0%	KALAMAZOO
116	5106	74.255	95.8%	WAYNE	166	5524	71.924	93.9%	WAYNE
117	2681	74.251	95.7%	MACOMB	167	5139	71.920	93.9%	WAYNE
118	5538	74.246	95.7%	WAYNE	168	5011	71.894	93.9%	WAYNE
119	5043	74.230	95.6%	WAYNE	169	5072	71.781	93.8%	WAYNE
120	0015	74.221	95.6%	KENT	170	5336	71.666	93.8%	WAYNE
121	5326	74.181	95.6%	WAYNE	171	5012	71.528	93.7%	WAYNE
122	5260	74.149	95.5%	WAYNE	172	5522	71.502	93.7%	WAYNE
123	0006	74.144	95.5%	BERRIEN	173	5175	71.450	93.7%	WAYNE
124	5034	73.977	95.5%	WAYNE	174	5342	71.448	93.6%	WAYNE
125	5180	73.816	95.4%	WAYNE	175	0003	71.424	93.6%	MUSKEGON
126	5186	73.801	95.4%	WAYNE	176	5185	71.392	93.6%	WAYNE
127	5218	73.780	95.4%	WAYNE	177	9851	71.372	93.5%	WAYNE
128	0015	73.689	95.3%	KALAMAZOO	178	0035	71.261	93.5%	KENT
129	0004	73.660	95.3%	MUSKEGON	179	5070	71.216	93.5%	WAYNE
130	1416	73.610	95.2%	OAKLAND	180	5184	71.171	93.4%	WAYNE
131	5013	73.571	95.2%	WAYNE	181	5523	71.086	93.4%	WAYNE
132	5141	73.500	95.2%	WAYNE	182	5262	71.044	93.3%	WAYNE
133	0003	73.495	95.1%	BERRIEN	183	2589	71.041	93.3%	MACOMB
134	5122	73.484	95.1%	WAYNE	184	5308	71.004	93.3%	WAYNE
135	5078	73.465	95.1%	WAYNE	185	0003	70.985	93.2%	CALHOUN
136	0021	73.428	95.0%	BERRIEN	186	1424	70.915	93.2%	OAKLAND
137	5213	73.425	95.0%	WAYNE	187	5792	70.854	93.2%	WAYNE
138	0006	73.292	95.0%	CALHOUN	188	5343	70.757	93.1%	WAYNE
139	5129	73.220	94.9%	WAYNE	189	0022	70.748	93.1%	BERRIEN
140	5166	73.216	94.9%	WAYNE	190	5303	70.653	93.1%	WAYNE
141	5231	73.150	94.8%	WAYNE	191	5113	70.649	93.0%	WAYNE
142	5168	73.103	94.8%	WAYNE	192	2642	70.632	93.0%	MACOMB
143	2471	73.074	94.8%	MACOMB	193	5319	70.556	92.9%	WAYNE
144	5156	72.989	94.7%	WAYNE	194	5123	70.511	92.9%	WAYNE
145	0041	72.892	94.7%	CALHOUN	195	0013	70.503	92.9%	MUSKEGON
146	0015	72.859	94.7%	KALAMAZOO	196	5534	70.479	92.8%	WAYNE
147	5215	72.792	94.6%	WAYNE	197	5264	70.271	92.8%	WAYNE
148	0005	72.741	94.6%	KALAMAZOO	198	5332	70.223	92.8%	WAYNE
149	5006	72.678	94.5%	WAYNE	199	5536	70.037	92.7%	WAYNE
150	5241	72.666	94.5%	WAYNE	200	5263	69.969	92.7%	WAYNE

Rank	Tract	EJ Score	Percentile	County	Rank	Tract	EJ Score	Percentile	County
201	4106	69.916	92.7%	WASHTENAW	251	4111	66.184	90.8%	WASHTENAW
202	5531	69.901	92.6%	WAYNE	252	5304	66.183	90.8%	WAYNE
203	5042	69.896	92.6%	WAYNE	253	5738	66.148	90.8%	WAYNE
204	5079	69.892	92.5%	WAYNE	254	2636	66.138	90.7%	MACOMB
205	5040	69.780	92.5%	WAYNE	255	0133	66.121	90.7%	KENT
206	5327	69.779	92.5%	WAYNE	256	5533	66.063	90.6%	WAYNE
207	0002	69.777	92.4%	CALHOUN	257	5361	65.989	90.6%	WAYNE
208	5010	69.680	92.4%	WAYNE	258	5064	65.902	90.6%	WAYNE
209	5211	69.567	92.4%	WAYNE	259	2621	65.806	90.5%	MACOMB
210	5786	69.155	92.3%	WAYNE	260	5392	65.623	90.5%	WAYNE
211	5318	69.142	92.3%	WAYNE	261	5378	65.517	90.5%	WAYNE
212	0008	69.117	92.2%	KENT	262	5214	65.477	90.4%	WAYNE
213	2684	68.971	92.2%	MACOMB	263	5706	65.468	90.4%	WAYNE
214	5002	68.921	92.2%	WAYNE	264	2450	65.437	90.4%	MACOMB
215	5137	68.904	92.1%	WAYNE	265	5456	65.425	90.3%	WAYNE
216	5257	68.821	92.1%	WAYNE	266	5316	65.364	90.3%	WAYNE
217	5532	68.808	92.1%	WAYNE	267	2634	65.331	90.2%	MACOMB
218	5365	68.772	92.0%	WAYNE	268	5373	65.327	90.2%	WAYNE
219	5071	68.572	92.0%	WAYNE	269	2400	65.306	90.2%	MACOMB
220	0066	68.546	92.0%	INGHAM	270	5315	65.247	90.1%	WAYNE
221	0011	68.483	91.9%	JACKSON	271	5007	65.202	90.1%	WAYNE
222	1421	68.459	91.9%	OAKLAND	272	1810	65.189	90.1%	OAKLAND
223	5001	68.381	91.8%	WAYNE	273	5383	65.187	90.0%	WAYNE
224	5073	68.362	91.8%	WAYNE	274	5014	65.156	90.0%	WAYNE
225	5126	68.184	91.8%	WAYNE	275	5074	65.107	90.0%	WAYNE
226	5372	67.970	91.7%	WAYNE	276	5202	65.091	89.9%	WAYNE
227	5317	67.956	91.7%	WAYNE	277	5390	65.000	89.9%	WAYNE
228	5341	67.835	91.7%	WAYNE	278	0005	64.915	89.8%	CALHOUN
229	5391	67.802	91.6%	WAYNE	279	5015	64.873	89.8%	WAYNE
230	5362	67.761	91.6%	WAYNE	280	5396	64.857	89.8%	WAYNE
231	5772	67.601	91.6%	WAYNE	281	2625	64.825	89.7%	MACOMB
232	5366	67.504	91.5%	WAYNE	282	1427	64.807	89.7%	OAKLAND
233	5124	67.474	91.5%	WAYNE	283	5735	64.722	89.7%	WAYNE
234	1423	67.440	91.4%	OAKLAND	284	2624	64.687	89.6%	MACOMB
235	5796	67.341	91.4%	WAYNE	285	2803	64.626	89.6%	BAY
236	0008	67.329	91.4%	INGHAM	286	5305	64.552	89.5%	WAYNE
237	5363	67.244	91.3%	WAYNE	287	5385	64.495	89.5%	WAYNE
238	5797	67.137	91.3%	WAYNE	288	0007	64.450	89.5%	SAGINAW
239	1420	67.109	91.3%	OAKLAND	289	5369	64.392	89.4%	WAYNE
240	5311	66.957	91.2%	WAYNE	290	5009	64.356	89.4%	WAYNE
241	5301	66.803	91.2%	WAYNE	291	1753	64.303	89.4%	OAKLAND
242	0004	66.774	91.2%	SAGINAW	292	5708	64.162	89.3%	WAYNE
243	5041	66.726	91.1%	WAYNE	293	0019	64.099	89.3%	SAGINAW
244	5005	66.697	91.1%	WAYNE	294	5368	64.035	89.3%	WAYNE
245	5153	66.681	91.0%	WAYNE	295	5737	64.002	89.2%	WAYNE
246	0020	66.596	91.0%	INGHAM	296	2452	63.967	89.2%	MACOMB
247	5743	66.528	91.0%	WAYNE	297	0014	63.933	89.1%	KENT
248	0014	66.400	90.9%	MUSKEGON	298	5008	63.925	89.1%	WAYNE
249	5455	66.333	90.9%	WAYNE	299	0004	63.864	89.1%	MUSKEGON
250	5339	66.207	90.9%	WAYNE	300	0028	63.564	89.0%	GENESEE

Rank	Tract	EJ Score	Percentile	County	Rank	Tract	EJ Score	Percentile	County
301	5352	63.492	89.0%	WAYNE	351	0036	61.066	87.2%	CALHOUN
302	0007	63.454	89.0%	INGHAM	352	5417	61.027	87.1%	WAYNE
303	5402	63.318	88.9%	WAYNE	353	0126	61.022	87.1%	KENT
304	2587	63.292	88.9%	MACOMB	354	0030	60.992	87.1%	KENT
305	0006	63.203	88.9%	INGHAM	355	5458	60.992	87.0%	WAYNE
306	5344	63.087	88.8%	WAYNE	356	5388	60.990	87.0%	WAYNE
307	5020	63.035	88.8%	WAYNE	357	5668	60.989	87.0%	WAYNE
308	5152	63.032	88.7%	WAYNE	358	0008	60.893	86.9%	SAGINAW
309	5734	63.022	88.7%	WAYNE	359	0038	60.854	86.9%	GENESEE
310	0029	62.976	88.7%	GENESEE	360	0029	60.772	86.8%	KENT
311	5856	62.961	88.6%	WAYNE	361	0613	60.759	86.8%	LENAWEE
312	0016	62.948	88.6%	KENT	362	5314	60.687	86.8%	WAYNE
313	5132	62.886	88.6%	WAYNE	363	5355	60.660	86.7%	WAYNE
314	5736	62.838	88.5%	WAYNE	364	0126	60.501	86.7%	KENT
315	2637	62.691	88.5%	MACOMB	365	5401	60.490	86.7%	WAYNE
316	0002	62.671	88.5%	JACKSON	366	5425	60.481	86.6%	WAYNE
317	5169	62.632	88.4%	WAYNE	367	0043	60.474	86.6%	INGHAM
318	1415	62.597	88.4%	OAKLAND	368	5387	60.469	86.6%	WAYNE
319	5364	62.530	88.3%	WAYNE	369	4101	60.437	86.5%	WASHTENAW
320	0017	62.509	88.3%	SAGINAW	370	0138	60.426	86.5%	KENT
321	5386	62.501	88.3%	WAYNE	371	5167	60.412	86.4%	WAYNE
322	0022	62.336	88.2%	GENESEE	372	5337	60.371	86.4%	WAYNE
323	4123	62.284	88.2%	WASHTENAW	373	5323	60.365	86.4%	WAYNE
324	0044	62.280	88.2%	INGHAM	374	0137	60.266	86.3%	KENT
325	5394	62.252	88.1%	WAYNE	375	0021	60.246	86.3%	INGHAM
326	0142	62.227	88.1%	KENT	376	5439	60.135	86.3%	WAYNE
327	0006	62.209	88.1%	SAGINAW	377	5312	60.104	86.2%	WAYNE
328	5775	62.144	88.0%	WAYNE	378	2559	60.057	86.2%	MACOMB
329	0205	62.112	88.0%	BERRIEN	379	5457	60.034	86.2%	WAYNE
330	4108	62.064	87.9%	WASHTENAW	380	0013	60.022	86.1%	SAGINAW
331	5302	62.045	87.9%	WAYNE	381	0010	59.995	86.1%	JACKSON
332	5347	61.996	87.9%	WAYNE	382	2305	59.975	86.0%	MACOMB
333	5423	61.973	87.8%	WAYNE	383	1724	59.943	86.0%	OAKLAND
334	5354	61.955	87.8%	WAYNE	384	5785	59.904	86.0%	WAYNE
335	5371	61.874	87.8%	WAYNE	385	5357	59.878	85.9%	WAYNE
336	5426	61.826	87.7%	WAYNE	386	5709	59.778	85.9%	WAYNE
337	4003	61.803	87.7%	WASHTENAW	387	0018	59.742	85.9%	SAGINAW
338	0138	61.731	87.7%	KENT	388	5771	59.701	85.8%	WAYNE
339	0012	61.659	87.6%	JACKSON	389	2635	59.647	85.8%	MACOMB
340	1751	61.606	87.6%	OAKLAND	390	0023	59.628	85.8%	GENESEE
341	5424	61.603	87.5%	WAYNE	391	5350	59.612	85.7%	WAYNE
342	5832	61.395	87.5%	WAYNE	392	5164	59.565	85.7%	WAYNE
343	5346	61.376	87.5%	WAYNE	393	5440	59.498	85.6%	WAYNE
344	5367	61.353	87.4%	WAYNE	394	5780	59.395	85.6%	WAYNE
345	5309	61.236	87.4%	WAYNE	395	5418	59.334	85.6%	WAYNE
346	1414	61.160	87.4%	OAKLAND	396	0026	59.308	85.5%	GENESEE
347	1409	61.114	87.3%	OAKLAND	397	0009	59.297	85.5%	SAGINAW
348	0006	61.106	87.3%	KALAMAZOO	398	2865	59.260	85.5%	BAY
349	5770	61.090	87.2%	WAYNE	399	0033	59.249	85.4%	INGHAM
350	5370	61.072	87.2%	WAYNE	400	5413	59.227	85.4%	WAYNE

401	0017	59.227	85.4%	GENESEE	451	0020	57.347	83.5%	GENESEE
402	5393	59.212	85.3%	WAYNE	452	5397	57.325	83.5%	WAYNE
403	5460	59.208	85.3%	WAYNE	453	5313	57.324	83.5%	WAYNE
404	5739	59.188	85.2%	WAYNE	454	5438	57.275	83.4%	WAYNE
405	2611	59.097	85.2%	MACOMB	455	1716	57.246	83.4%	OAKLAND
406	5516	59.039	85.2%	WAYNE	456	5421	57.241	83.3%	WAYNE
407	5353	58.991	85.1%	WAYNE	457	5704	57.173	83.3%	WAYNE
408	0011	58.929	85.1%	KALAMAZOO	458	4117	57.169	83.3%	WASHTENAW
409	5685	58.915	85.1%	WAYNE	459	5469	57.151	83.2%	WAYNE
410	5414	58.843	85.0%	WAYNE	460	0021	57.133	83.2%	KENT
411	2561	58.840	85.0%	MACOMB	461	0209	57.133	83.2%	BERRIEN
412	5453	58.824	85.0%	WAYNE	462	5408	57.129	83.1%	WAYNE
413	0006	58.796	84.9%	JACKSON	463	0136	57.059	83.1%	KENT
414	5422	58.779	84.9%	WAYNE	464	2629	57.049	83.1%	MACOMB
415	5351	58.763	84.8%	WAYNE	465	0008	57.038	83.0%	MUSKEGON
416	5154	58.761	84.8%	WAYNE	466	0249	56.899	83.0%	OTTAWA
417	0013	58.694	84.8%	JACKSON	467	5016	56.866	82.9%	WAYNE
418	5461	58.691	84.7%	WAYNE	468	5669	56.858	82.9%	WAYNE
419	5403	58.661	84.7%	WAYNE	469	5670	56.820	82.9%	WAYNE
420	0009	58.646	84.7%	KENT	470	0023	56.804	82.8%	BERRIEN
421	5705	58.627	84.6%	WAYNE	471	5375	56.804	82.8%	WAYNE
422	5381	58.618	84.6%	WAYNE	472	1814	56.622	82.8%	OAKLAND
423	4001	58.562	84.5%	WASHTENAW	473	0032	56.575	82.7%	INGHAM
424	5459	58.560	84.5%	WAYNE	474	0011	56.562	82.7%	GENESEE
425	5019	58.542	84.5%	WAYNE	475	0055	56.537	82.7%	KALAMAZOO
426	5395	58.521	84.4%	WAYNE	476	5415	56.505	82.6%	WAYNE
427	0067	58.512	84.4%	INGHAM	477	5710	56.451	82.6%	WAYNE
428	5404	58.449	84.4%	WAYNE	478	1981	56.386	82.5%	OAKLAND
429	0136	58.444	84.3%	GENESEE	479	1425	56.298	82.5%	OAKLAND
430	0015	58.373	84.3%	GENESEE	480	5837	56.297	82.5%	WAYNE
431	5389	58.334	84.3%	WAYNE	481	0013	56.289	82.4%	CALHOUN
432	5376	58.318	84.2%	WAYNE	482	0020	56.264	82.4%	BERRIEN
433	5773	58.210	84.2%	WAYNE	483	2553	56.213	82.4%	MACOMB
434	5411	58.124	84.1%	WAYNE	484	5377	56.201	82.3%	WAYNE
435	2557	58.072	84.1%	MACOMB	485	4005	56.199	82.3%	WASHTENAW
436	4002	58.051	84.1%	WASHTENAW	486	5451	56.180	82.2%	WAYNE
437	0025	57.984	84.0%	KENT	487	2680	56.119	82.2%	MACOMB
438	0127	57.975	84.0%	KENT	488	0222	56.095	82.2%	OTTAWA
439	0044	57.928	84.0%	INGHAM	489	2451	56.025	82.1%	MACOMB
440	5017	57.841	83.9%	WAYNE	490	2556	55.891	82.1%	MACOMB
441	0045	57.831	83.9%	KENT	491	2558	55.889	82.1%	MACOMB
442	0001	57.801	83.9%	SAGINAW	492	5165	55.886	82.0%	WAYNE
443	2413	57.772	83.8%	MACOMB	493	4021	55.849	82.0%	WASHTENAW
444	4119	57.759	83.8%	WASHTENAW	494	5737	55.778	82.0%	WAYNE
445	8318	57.670	83.7%	MONROE	495	5466	55.715	81.9%	WAYNE
446	8319	57.640	83.7%	MONROE	496	4022	55.708	81.9%	WASHTENAW
447	2628	57.589	83.7%	MACOMB	497	0001	55.673	81.8%	INGHAM
448	2454	57.580	83.6%	MACOMB	498	5018	55.622	81.8%	WAYNE
449	2807	57.553	83.6%	BAY	499	5742	55.464	81.8%	WAYNE
450	1815	57.401	83.6%	OAKLAND	500	0032	55.371	81.7%	GENESEE

Rank	Tract	EJ Score	Percentile	County	Rank	Tract	EJ Score	Percentile	County
501	5405	55.338	81.7%	WAYNE	551	5452	53.649	79.9%	WAYNE
502	5356	55.316	81.7%	WAYNE	552	5443	53.646	79.8%	WAYNE
503	5462	55.266	81.6%	WAYNE	553	5664	53.587	79.8%	WAYNE
504	2586	55.258	81.6%	MACOMB	554	0014	53.366	79.8%	GENESEE
505	0616	55.235	81.6%	LENAWEE	555	2617	53.320	79.7%	MACOMB
506	2583	55.214	81.5%	MACOMB	556	0004	53.318	79.7%	GENESEE
507	1725	55.200	81.5%	OAKLAND	557	2566	53.272	79.7%	MACOMB
508	0046	55.179	81.4%	KENT	558	5842	53.212	79.6%	WAYNE
509	5407	55.165	81.4%	WAYNE	559	5776	53.149	79.6%	WAYNE
510	0140	55.038	81.4%	KENT	560	0041	53.116	79.5%	INGHAM
511	2620	55.024	81.3%	MACOMB	561	2619	53.110	79.5%	MACOMB
512	0613	55.014	81.3%	LENAWEE	562	1603	53.084	79.5%	OAKLAND
513	5454	54.991	81.3%	WAYNE	563	0035	52.974	79.4%	INGHAM
514	2564	54.949	81.2%	MACOMB	564	2582	52.971	79.4%	MACOMB
515	5467	54.936	81.2%	WAYNE	565	0008	52.969	79.4%	GENESEE
516	5437	54.923	81.2%	WAYNE	566	0002	52.938	79.3%	SAGINAW
517	0026	54.919	81.1%	CALHOUN	567	0018	52.876	79.3%	KALAMAZOO
518	5464	54.860	81.1%	WAYNE	568	2610	52.691	79.3%	MACOMB
519	5412	54.846	81.0%	WAYNE	569	0029	52.675	79.2%	KALAMAZOO
520	2562	54.838	81.0%	MACOMB	570	5859	52.659	79.2%	WAYNE
521	1752	54.769	81.0%	OAKLAND	571	5818	52.605	79.1%	WAYNE
522	0017	54.769	80.9%	KALAMAZOO	572	0129	52.487	79.1%	KENT
523	2588	54.731	80.9%	MACOMB	573	5514	52.413	79.1%	WAYNE
524	0258	54.698	80.9%	OTTAWA	574	5428	52.407	79.0%	WAYNE
525	0147	54.666	80.8%	KENT	575	0207	52.399	79.0%	BERRIEN
526	2563	54.656	80.8%	MACOMB	576	2257	52.381	79.0%	MACOMB
527	0010	54.621	80.8%	KENT	577	0114	52.253	78.9%	KENT
528	5207	54.545	80.7%	WAYNE	578	1713	52.218	78.9%	OAKLAND
529	0069	54.518	80.7%	JACKSON	579	1816	52.159	78.9%	OAKLAND
530	0007	54.405	80.6%	GENESEE	580	2316	52.156	78.8%	MACOMB
531	6260	54.391	80.6%	SAINT CLAIR	581	1410	52.104	78.8%	OAKLAND
532	5779	54.383	80.6%	WAYNE	582	0009	52.080	78.7%	JACKSON
533	2627	54.362	80.5%	MACOMB	583	5441	52.069	78.7%	WAYNE
534	1426	54.254	80.5%	OAKLAND	584	1611	52.004	78.7%	OAKLAND
535	0012	54.250	80.5%	INGHAM	585	2317	51.985	78.6%	MACOMB
536	5554	54.207	80.4%	WAYNE	586	0016	51.962	78.6%	GENESEE
537	2323	54.164	80.4%	MACOMB	587	5665	51.881	78.6%	WAYNE
538	0065	54.036	80.4%	INGHAM	588	5541	51.846	78.5%	WAYNE
539	1413	54.029	80.3%	OAKLAND	589	5717	51.826	78.5%	WAYNE
540	5774	53.986	80.3%	WAYNE	590	5435	51.799	78.5%	WAYNE
541	0134	53.969	80.2%	KENT	591	5520	51.773	78.4%	WAYNE
542	5442	53.930	80.2%	WAYNE	592	0012	51.575	78.4%	GENESEE
543	5427	53.831	80.2%	WAYNE	593	0143	51.535	78.3%	KENT
544	5409	53.812	80.1%	WAYNE	594	2221	51.525	78.3%	MACOMB
545	4112	53.763	80.1%	WASHTENAW	595	0004	51.447	78.3%	INGHAM
546	0324	53.734	80.1%	ALLEGAN	596	5848	51.434	78.2%	WAYNE
547	5855	53.709	80.0%	WAYNE	597	2804	51.432	78.2%	BAY
548	0026	53.681	80.0%	INGHAM	598	0009	51.323	78.2%	GENESEE
549	5468	53.671	80.0%	WAYNE	599	5436	51.297	78.1%	WAYNE
550	0007	53.668	79.9%	CALHOUN	600	0122	51.245	78.1%	GENESEE

Rank	Tract	EJ Score	Percentile	County	Rank	Tract	EJ Score	Percentile	County
601	1813	51.231	78.1%	OAKLAND	651	5465	48.743	76.2%	WAYNE
602	2416	51.150	78.0%	MACOMB	652	5719	48.692	76.2%	WAYNE
603	5434	51.147	78.0%	WAYNE	653	2623	48.685	76.2%	MACOMB
604	0040	51.100	77.9%	GENESEE	654	0011	48.635	76.1%	SAGINAW
605	4042	51.070	77.9%	WASHTENAW	655	0252	48.555	76.1%	OTTAWA
606	5410	50.998	77.9%	WAYNE	656	5463	48.495	76.0%	WAYNE
607	0010	50.973	77.8%	CALHOUN	657	5683	48.403	76.0%	WAYNE
608	0020	50.959	77.8%	SAGINAW	658	4105	48.392	76.0%	WASHTENAW
609	0006	50.928	77.8%	GENESEE	659	1621	48.388	75.9%	OAKLAND
610	5831	50.853	77.7%	WAYNE	660	5406	48.386	75.9%	WAYNE
611	1974	50.800	77.7%	OAKLAND	661	5171	48.332	75.9%	WAYNE
612	1622	50.630	77.7%	OAKLAND	662	0013	48.298	75.8%	GENESEE
613	2421	50.363	77.6%	MACOMB	663	0036	48.295	75.8%	INGHAM
614	4107	50.329	77.6%	WASHTENAW	664	5721	48.216	75.8%	WAYNE
615	0026	50.273	77.5%	MUSKEGON	665	4103	48.159	75.7%	WASHTENAW
616	2324	50.220	77.5%	MACOMB	666	4140	48.151	75.7%	WASHTENAW
617	0037	50.212	77.5%	GENESEE	667	0212	48.095	75.6%	BERRIEN
618	2308	50.107	77.4%	MACOMB	668	5555	48.084	75.6%	WAYNE
619	0021	50.102	77.4%	MUSKEGON	669	5724	48.064	75.6%	WAYNE
620	2417	50.060	77.4%	MACOMB	670	2408	47.970	75.5%	MACOMB
621	0037	50.049	77.3%	INGHAM	671	5649	47.963	75.5%	WAYNE
622	5170	50.038	77.3%	WAYNE	672	4110	47.960	75.5%	WASHTENAW
623	5733	50.009	77.2%	WAYNE	673	5857	47.943	75.4%	WAYNE
624	5718	50.000	77.2%	WAYNE	674	0022	47.935	75.4%	KENT
625	0036	49.975	77.2%	GENESEE	675	5836	47.895	75.4%	WAYNE
626	5157	49.891	77.1%	WAYNE	676	0002	47.855	75.3%	GENESEE
627	4120	49.846	77.1%	WASHTENAW	677	0035	47.750	75.3%	CALHOUN
628	5432	49.749	77.1%	WAYNE	678	5430	47.736	75.2%	WAYNE
629	0135	49.700	77.0%	GENESEE	679	2314	47.730	75.2%	MACOMB
630	5862	49.623	77.0%	WAYNE	680	6240	47.712	75.2%	SAINT CLAIR
631	2412	49.542	77.0%	MACOMB	681	0013	47.639	75.1%	KALAMAZOO
632	6250	49.499	76.9%	SAINT CLAIR	682	5701	47.627	75.1%	WAYNE
633	0010	49.491	76.9%	SAGINAW	683	0011	47.590	75.1%	KENT
634	0306	49.400	76.8%	SHIAWASSEE	684	0041	47.583	75.0%	KENT
635	5778	49.382	76.8%	WAYNE	685	4130	47.562	75.0%	WASHTENAW
636	0001	49.348	76.8%	MUSKEGON	686	1454	47.556	75.0%	OAKLAND
637	5830	49.283	76.7%	WAYNE					
638	0027	49.237	76.7%	GENESEE					
639	5542	49.217	76.7%	WAYNE					
640	0033	49.170	76.6%	KENT					
641	0322	49.164	76.6%	ALLEGAN					
642	2476	49.164	76.6%	MACOMB					
643	0202	49.138	76.5%	EATON					
644	0053	49.136	76.5%	INGHAM					
645	4026	49.087	76.4%	WASHTENAW					
646	0010	49.064	76.4%	GENESEE					
647	0016	49.024	76.4%	SAGINAW					
648	0141	48.966	76.3%	KENT					
649	2309	48.955	76.3%	MACOMB					
650	2552	48.786	76.3%	MACOMB					

Designing the mid-transition: A review of medium-term challenges for coordinated decarbonization in the United States

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Edited by: Simone Pulver, Domain Editor, and Mike Hulme, Editor-in-Chief

Abstract

Decarbonizing the energy system is critical for addressing climate change. Given the dominance of fossil fuels in the energy system, decarbonization requires rapid and significant industrial transition of the energy supply at scale. This includes explicit and coordinated plans not only for zero carbon phase-in, but for fossil carbon phase-out. Even very rapid decarbonization will likely take decades, leading to a medium-term future where the conventional, fossil-based energy system coexists with a new, zero-carbon energy system. Each imposes operational constraints on the other: what we call the mid-transition. Notably, this coexistence means that the new, zero-carbon system will develop under fossil carbon system constraints. The mid-transition will therefore likely require specific analytical metrics designed to support decision making under dynamic and uncertain conditions. Many aspects of transition will be felt, and shaped, directly by individuals because of our direct interactions with energy systems. Even rare missteps are likely to have significant and potentially system design-relevant impacts on perception, political support, and implementation. Comparisons of the new system to the old system are likely to rest on experience of a world less affected by climate change, such that concerns about lower reliability, higher costs, and other challenges might be perceived as inherent to zero-carbon systems, versus energy systems facing consequences of climate change and long-term underinvestment. This review assesses and evaluates medium-term challenges associated with the mid-transition in the United States, emphasizing the need for explicit planning for joint and coordinated phase-in and phase-out.

This article is categorized under:

- The Carbon Economy and Climate Mitigation > Decarbonizing Energy and/or Reducing Demand

KEYWORDS

decarbonization, deindustrialization, fossil fuels, macroenergy systems, transition

1 | INTRODUCTION

Decarbonizing human activities, particularly via the energy system, is a crucial task for stopping anthropogenic contributions to ongoing climate change (Davis et al., 2018; Intergovernmental Panel on Climate Change, 2021; Rissman

et al., 2020; Williams et al., 2021). Decarbonization requires rapid and significant supply-side industrial transition at scale, both to build out new systems and to retire existing ones (Geels et al., 2017; Grubert, 2020b; McGlade et al., 2018; Rissman et al., 2020; Williams et al., 2021; Zhao & Alexandroff, 2019). The potential scale of this industrialization required for decarbonized energy systems depends heavily, however, on the degree to which demand-side options are exercised (Pye et al., 2021). Although processes to create and deploy new industrial facilities are widely researched and reviewed, research explicitly focused on phasing out existing, carbon-emitting infrastructure, and the effects of doing so, is much less common (Rosenbloom & Rinscheid, 2020). Such research largely focuses on restricting future fossil fuel extraction and use (Buck, 2021; Muttitt & Kartha, 2020; Piggot et al., 2018; Piggot et al., 2020; Zhao & Alexandroff, 2019) or lessons and frameworks from the deconstruction of previous industries (Normann, 2019; Turnheim & Geels, 2013). Detailed research and modeling focused on issues like anticipated future energy prices (and potential price shocks) under decline; capital investment trajectories; remediation and reclamation triggers and implementation; labor and training requirements; and minimum viable scale for conventional energy systems—questions crucial to investigate if we assume we will successfully decarbonize—are notably missing from the literature.

Lack of attention to coordinated planning for joint phase-in of zero-carbon and phase-out of fossil fuel-based systems and the associated infrastructure that enables emissions generation represents a major risk to a successful, just energy transition (Wang & Lo, 2021) on the rapid timelines required to reach domestic US (The White House, 2021b) and international climate goals (Intergovernmental Panel on Climate Change, 2021). This risk is particularly due to the social embeddedness and material and political dominance of existing, emitting fossil fuel systems that create carbon lock-in (Unruh, 2000; Wang & Lo, 2021). Without explicit planning, the transition is likely to face major challenges like local economic busts, highly inequitable access to high quality energy and infrastructure systems, and poor coordination for system-level characteristics like reliability, accessibility, and affordability. Already, evidence from the uncoordinated US coal transition shows increased potential for negative outcomes like economic hardship (e.g., from lost tax revenues and jobs), unfunded obligations (e.g., pensions, remediation commitments, maintenance and monitoring), identity and governance disruptions, and loss of resilience (Haggerty et al., 2018; Macey & Salovaara, 2019; Roemer & Haggerty, 2021).

During the transition period where zero-carbon and emitting fossil fuel systems co-exist at scales where each imposes operationally relevant constraints on the other, which we call the mid-transition in this review, success and justice will require explicit planning underpinned by specialized metrics for coordinated zero-carbon infrastructure ramp-up and emissions-enabling fossil infrastructure phase-out. During the mid-transition, neither zero-carbon nor carbon-emitting infrastructure can fully support all energy services on its own, and the overall system is not optimized for either infrastructure's sociotechnical particularities. Risks of maladaptations, overlooked opportunities for synergies, and uncoordinated decision-making are high during the mid-transition, particularly as infrastructures encounter simultaneous climate, technology, and societal dynamics that are not well characterized by past experience. For example, renewable electricity systems might develop with the assumption that natural gas backup generators will always be available to provide low-cost grid support services (Phadke et al., 2020; Williams et al., 2021), or gas stations in a given region might all face simultaneous loss of profitability past a certain penetration of electric vehicles. System performance metrics and other evaluative tools designed specifically for dynamics of the transition will be needed to both measure progress and identify emergent challenges in time to address them, particularly since some constraints can be more easily temporarily relaxed in pursuit of long-term benefit (e.g., short-term cost increases counterbalanced by long-term cost savings and market structures attentive to impacts on energy burden) than others (e.g., safety and reliability).

Even decarbonization rapid enough to pose challenges for responsible acceleration (Skjølsvold & Coenen, 2021) will likely take decades (Williams et al., 2021), creating a significant time over which failure to coordinate could exacerbate existing structural challenges (Wang & Lo, 2021) and create new ones. Energy transitions, including the present decarbonization transition, have historically been slow (Fouquet, 2016). Global carbon intensity of energy has been flat for decades, and fossil fuels still supply about 80% of marketed energy (Hanna & Victor, 2021). Large increases in contributions from renewable resources in the United States and elsewhere have largely been in addition to, rather than instead of, ongoing use of unabated fossil fuels, particularly under demand growth.

Although policy tends to treat the transition as a “problem of addition” (Aronoff et al., 2020), in practice, the decarbonization transition cannot be completed without de-carbonization, which means that companies, livelihoods, and ways of life associated with emissions-enabling fossil fuel infrastructure and systems will disappear. In addition to obvious challenges like job and revenue losses, this disappearance (and anticipation thereof) could enable very concrete, potentially distressing sociotechnical imaginaries and identity threats for those engaged in fossil-dependent activities (Grubert & Skinner, 2017; Jasanoff & Kim, 2009; Smith, 2019) while creating the conditions for resistance to the transition from incumbent regime actors (Geels, 2014) and ultimately slowing the transition. Efforts to enact a just transition

(Chapman et al., 2018; Evans & Phelan, 2016; McCauley & Heffron, 2018; Newell & Mulvaney, 2013; Wang & Lo, 2021; White, 2020) are challenged by the need to transition rapidly while also recognizing acceleration as a key challenge for trust-based, just, and participatory processes enabling coproduction and respect for deeply held values (Haggerty et al., 2018; Skjølsvold & Coenen, 2021). Prior transitions in specific regions (e.g., in Appalachia) have demonstrated the potential for very negative outcomes associated with violent, high conflict processes with long-term effects, like poverty and mistrust (Hess et al., 2021). That is: even assuming widespread support for transitions in concept, success—and particularly success characterized by justice and improved societal conditions—is by no means guaranteed.

Although challenges of transition are widely recognized in the Society and Technology Studies (STS), geography, and broader energy and natural resource social sciences literatures (e.g., Carley et al., 2018; Colvin, 2020; Haggerty et al., 2018; C. A. Miller et al., 2013; Miller et al., 2015; Roberts et al., 2018; Smith & Tidwell, 2016), explicit attention to the logistics of the mid-transition is rare in policy, models, and other structures granted authoritative status. This review investigates issues of the mid-transition in the United States in an effort to highlight the need for such attention. In Section 2, we define the mid-transition and motivate the need to design it. In Section 3, we characterize the technical context of the mid-transition. In Section 4, we review the social context of the mid-transition. We conclude with recommendations for analyzing the mid-transition and envisioning the post-transition world.

2 | WHAT IS THE MID-TRANSITION?

Here, we define the mid-transition to be the period during which energy supply—in this review, focused on the US energy system—is (1) constrained by a goal of reducing or eliminating greenhouse gas emissions and (2) comprised of fossil carbon-emitting systems and zero-carbon systems that both exist at sufficient scale to impose operationally relevant constraints on the other. That is, the mid-transition is the period between two stable end points (where systems are largely operating as they were designed and under conditions structured around their needs) during which change is directional and coexisting systems must make compromises to accommodate the other. (See Section 3 for a discussion of technical parameters that could identify the mid-transition.)

BOX 1 How does carbon-based infrastructure fit into the mid-transition framework?

Modeling efforts widely suggest that decarbonized energy supplies are likely to be dominated by non-carbon-based infrastructure, which in turn suggests carbon-based systems will shrink. In theory, however, there are many pathways to decarbonization, including those where carbon-based infrastructure is used to decarbonize and could thus expand. For example, a fully fossil-fueled energy supply could theoretically be greenhouse gas neutral via extremely carbon capture and storage (CCS)-dependent energy systems that also include fossil fuel-fired carbon dioxide removal (CDR), like direct air capture and storage (DACS). Such pathways would not eliminate other impacts of fossil fuels, and they would rely on much larger use of depletable fuels while also requiring substantial CO₂ transportation and storage networks, but they are possible. Pathways combining carbon-emitting and zero carbon-based systems would still undergo a mid-transition characterized by operational concessions from both emitting and non-emitting infrastructures. For example, CCS and DACS are both energy intensive, and these supplies and loads would be prioritized under a decarbonization constraint. Note also that decarbonization is potentially achievable without a complete transition. That is, a decarbonized system could remain indefinitely in a state of mid-transition where carbon-emitting and zero-carbon infrastructures coexist and constrain one another. Imagine a setting where unabated natural gas-fired power plants continue to operate at meaningful scales, with emissions compensated by CDR (via DACS or other pathways): this setting might be decarbonized, but still constrained by qualitatively different infrastructures accommodating one another, for example, via allocation of marginal renewable power to compensatory CDR and rapid ramping of natural gas-fired power plants. Both the carbon-based and perpetual mid-transition pathways to decarbonization are possible but likely less optimal than deeper phase-out of fossil fuel infrastructure, based on current understanding of costs and non-climate impacts. For a thoughtful treatment of some of these issues, including the relational and material context of fossil industry transformation, see (Buck, 2021).

As the transition progresses, carbon-based infrastructures are expected to shrink (see Box 1), potentially leading to loss of certain economies of scale, while the zero-carbon system grows, potentially encountering emergent economies and diseconomies of scale. In a future, mostly zero-carbon system, carbon-emitting components might require operational accommodations from the zero-carbon portion of the energy system, but what these accommodations might be is not completely clear yet. In defining the mid-transition as policy-meaningful, we aim to investigate the kinds of emergent dynamics that might be both anticipatable and mitigatable, given the rapid but still decade-scale planning processes at play.

2.1 | Why design the mid-transition?

The need to design the mid-transition as a national process (in addition to designing local end-point transitions; Haggerty et al., 2018) is emphasized by the potential for weak medium-term policies to increase both the cost of transition and the likelihood of locking in carbon intensive policies (Hidalgo-Gonzalez et al., 2021). Single-target policies without interim checkpoints, like “zero carbon by X”, do not necessarily foster near-term actions compatible with the eventual policy goal, especially when penalties are unclear and no phase-out is required. Similarly, emissions reductions goals, like “80% reductions in GHG emissions by X,” might not be compatible with long-term goals of reaching 0 GHG emissions if they encourage investment in long-lived infrastructures that achieve the interim goal but cannot achieve the ultimate goal, or if they do not encourage disinvestment in existing, incompatible systems.

From a resource allocation standpoint, complying with an 80% GHG reduction target by decarbonizing 80% of the system is very different from complying by investing in new systems that emit 20% as much GHG, or investing in technologies that could attain emissions reductions but not explicitly designing the transition away from emissions intensive activities. Recognizing this dynamic of “bridging” rationalities contributing to delays (Low & Boettcher, 2020), particularly as existing legacy infrastructure liabilities (like pipeline networks) become meaningful cost burdens as stranded assets (Bos & Gupta, 2019) that could have particularly high impacts on the least wealthy (Grubert, 2020b), is important for designing the mid-transition.

As one example, consider the proposed decarbonization sequence of a coal-to-gas switch, then a gas-to-renewable natural gas (RNG) switch: in neither case does the infrastructural investment actually enable an eventual zero GHG goal, because neither natural gas nor RNG (Grubert, 2020a) is zero GHG at scale. Thus, not only interim goals, but also interim goals with an explicit pathway to zero are needed. Careful evaluation of whether allocating resources to incumbents to reduce emissions rather than invest in pathways to eliminating them (e.g., investing in low hazard methane leak reduction or low-carbon gases rather than building electrification, even if the near-term emissions benefits are similar or favor the pathway that does not include a path to zero), should be the charge of regulators, policy makers, and advocates during the mid-transition.

The mid-transition requires design because phase in and phase out must be aligned in time, with multiscale challenges associated with continuing to provide crucial services while emphasizing sustainability and justice. These challenges are heavily affected and amplified by the need for the rapid transformation of entire systems (e.g., from highly centralized to a centralized and decentralized mix), and with the introductions of new interactions between historically siloed sub energy systems with disparate governance and institutional structures (e.g., through the electrification of sectors previously dependent on liquid fuels). How well does academic research support these challenging design problems of simultaneous zero-carbon phase in and carbon phase out? Although the literature touches on some explicit efforts to intentionally eliminate industries (Haas & Sander, 2016; Haggerty et al., 2018; Hess et al., 2021; Huang & Chen, 2021; Zhao & Alexandroff, 2019), largely associated with coal and nuclear fleets with widely understood negative local impacts, the scope of contraction addressed by this type of research is quite limited relative to the decarbonization of the energy system as a whole. In addition, these examples largely involve a one for one replacement of infrastructure and technology with an alternative with relatively similar parameters. In general, academic research has devoted limited attention to the “how” of de-transition—the practical operational and political constraints of carbon phase out (though see Buck, 2021; Grubert, 2020b; McGlade et al., 2018; Mildenerberger, 2020; Pai, Zerrieffi, et al., 2020). By contrast, similarly practical issues related to industrialization are relatively carefully covered, including by influential studies that derive authority in part from their detailed underlying technical and theoretical models (Davis et al., 2018; Geels et al., 2017; Jacobson et al., 2015; E. Larson et al., 2020; Mayfield et al., 2021; Phadke et al., 2020; Williams et al., 2021). This gap is significant, and urgent, given both the pace and extreme complexity of successful alignment of resources to achieve decarbonization.

2.2 | What is the design goal? Normativity in sustainability-oriented transitions

Sustainability transition studies emphasize the status of sustainability-oriented transition as a political process: that is, such transitions have normative goals (e.g., zero GHG emissions) to be achieved in nonlinear, multisystem, and multiscale processes under high uncertainty and high degrees of contestation (Geels, 2011; Köhler et al., 2019). One implication of normativity is that there is an explicit design goal: in this case, elimination of greenhouse gas emissions. Thus, progress toward the goal can be measured, in addition to typical “snapshot” style descriptive technical measurements. Similarly, decisions can be evaluated for compatibility with the goal, using a directed understanding of mechanisms of influence and contestation. The mechanisms through which the decarbonization process can be influenced—a combination of “technologies, institutions, and behavioral norms” that create carbon lock-in—are understood (Seto et al., 2016). Contestation arises in part from the fact that the normative goal of decarbonization is misaligned with private incentives. For example, fossil fuel companies have limited private incentives to decarbonize absent a strong market signal, and instead resist decarbonization where it threatens their market share, and user benefits of transition might be unclear (Geels, 2011). Particularly in fields that often (falsely) suggest research is value-free (Grubert, 2017a; Rykiel, 2001), acknowledging that decarbonization is a normative transition could inform more design-relevant research that incorporates these mechanisms.

On its face, the decarbonization transition is largely motivated by a need to reduce environmental harms—most obviously those associated with climate change—rather than to provide obvious and immediate benefits like a new service, like air conditioning, that was characterized by rapid uptake (Sovacool, 2016). One crucial point, though, is that in practice, largely because of the deep integration of carbon-emitting systems into society, decarbonization entails a remaking of the energy system that encompasses the potential for deep, structural, and multicriteria changes that go well beyond the core goal of eliminating greenhouse gas emissions and reducing climate harm (see, e.g., Eschrich & Miller, 2021). That is, “the” normative goal of decarbonization is, in practice, a diverse set of multicriteria normative goals for various socioenvironmental outcomes, with a shared goal focused on greenhouse gases. The multiplicity of values and directions associated with this transition lead both to additional areas of contestation and to significant opportunities for visioning and decision support that can enable thoughtful choices about major infrastructures with deep implications for sustainability, justice, and societal structures.

Notably, the societal embeddedness of carbon-producing systems means that transition enables not only environmental harm reduction, like limiting climate change, reducing air pollution, and otherwise reducing environmental harms with health, safety, ecosystem, and other consequences (Anderson et al., 2018; Chapman et al., 2018; Ekholm et al., 2014; Hertwich et al., 2014), but also the potential for actively and normatively improving socioenvironmental outcomes by reversing injustices, structuring systems to provide higher quality of life, and other mechanisms. Goals beyond decarbonization itself, however, are less obviously shared, less clearly envisioned as concrete sociotechnical imaginaries (Jasanoff & Kim, 2009), and less easily characterized by authoritative metrics accepted as valid than are greenhouse gas emissions reductions. One major task for decarbonization researchers, then, must be to ask both: what is success, and what would we study if we took the prospect of that success seriously? Although this review focuses somewhat narrowly on evaluating the decarbonization transition from a technical and greenhouse gas emissions-focused perspective, we note that designing the mid-transition matters not only because of emissions trajectories, but also because of the deep structural implications of the specific transition pathways that are ultimately undertaken.

3 | TECHNICAL CONTEXT OF THE MID-TRANSITION

In order to assess and improve outcomes during the mid-transition, we first need to identify when a system is in the mid-transition state. We propose the mid-transition be quantified in terms of the percent penetration of the new system on a relevant and easily identified metric, like percentage of total energy provision, or total infrastructure deployed. In this case the mid-transition period starts when the penetration of the new infrastructure reaches a level where it imposes operationally meaningful constraints on the existing system through incompatible characteristics. The mid-transition period ends when the new infrastructure is sufficiently dominant that it is no longer meaningfully constrained from optimal operation by the legacy infrastructure.

Further analysis is required to define appropriate mid-transition cut-off metrics that characterize conditions when systems meaningfully constrain each other. As a rule of thumb for identifying when an energy supply system is in the mid-transition, we suggest the period of roughly 20%–80% penetration on a supplied-energy basis. Although this rule of

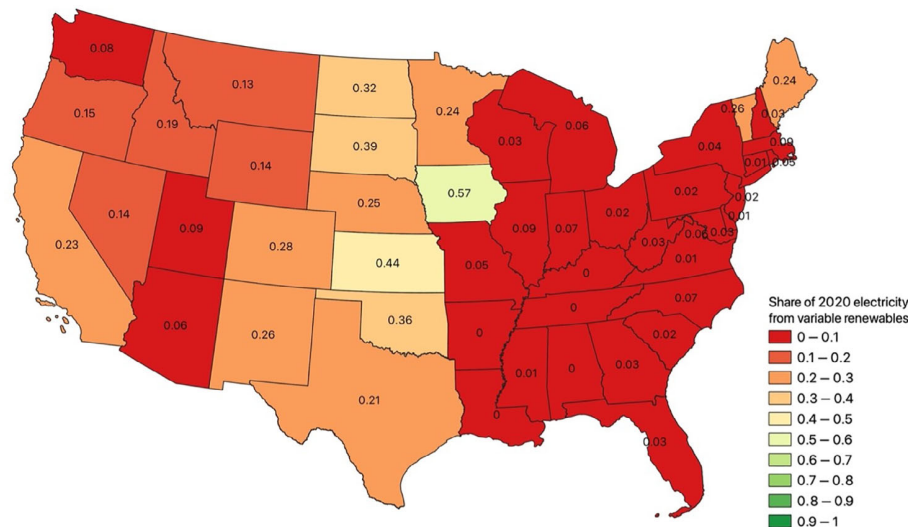


FIGURE 1 Some US states already have >20% variable renewable electricity penetration, a sign they might have entered the mid-transition. Note that total zero-carbon electricity rates are higher but conventional zero-carbon electricity is adapted to the previous system. Source: EIA 860/923

thumb is extremely coarse and should be empirically tested for compatibility with the results-oriented definition emphasizing when systems constrain each other, it is supported by some prior observations. For example, the current energy system is approximately 80% fossil fuel-based (Hanna & Victor, 2021), suggesting that 80% is a reasonable threshold for identifying a system as dominant. Supporting the notion that 20% penetration by a qualitatively different system becomes operationally disruptive, the California “duck chart” identifies a phenomenon where, around 20% of annual energy being provided by solar, the conventional system is highly challenged by the need for fast ramping at the same time as its business-as-usual constraints lead to large (>30%) marginal curtailment rates for the emerging solar system (Denholm et al., 2015). In the United States, some electricity systems are at the beginning of the mid-transition from fossil-based power systems to variable renewable electricity (VRE) systems under this rule-of-thumb (recognizing that VRE is not the only possible end-dominant system for electricity, and also that in both cases, infrastructure like hydroelectricity or other potential “clean firm” generation resources might not belong neatly to the operationally dominant system), whereas transportation and industrial heat have not yet entered the mid-transition (Figure 1).

Under the timelines suggested by current US climate targets, all energy systems are expected to rapidly enter and traverse the mid-transition (by 2035 for electricity; by 2050 for all energy systems). For perspective, the time left between now and 2050—when the United States aims to achieve full decarbonization of the economy (net-zero emissions), and roughly when global net zero is advised if warming is to be limited to 1.5°C (Intergovernmental Panel on Climate Change, 2021)—is roughly the same as the time between the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and now. Success, then, requires a very rapid mid-transition relative to historical pace.

3.1 | Technical heuristics for the mid-transition

Particularly in the context of a normative, goal-oriented decarbonization transition, one major consideration for the mid-transition is whether currently applied heuristics serve our design, deployment, and maintenance systems well. Heuristics that have historically served well as proxies for endpoint indicators of interest, like successful provision of energy systems, might not be fit-for-purpose at various points in the mid-transition, or long-term as we transition to a fully zero-carbon system (though note that ongoing climate dynamics are likely to continue to require flexibility).

Metrics like heat rate (or thermal efficiency), historically related to intuition about energy costs, do not make sense for nonthermal systems—especially those with free fuel. The idea of dispatching the plants with highest conversion efficiency first makes very little sense for wind and solar plants. Broader and more deeply embedded heuristics, like general concepts of what is needed or available to promote grid reliability (e.g., supply side only versus supply and

demand), or the idea that energy extracted at a particular site becomes more expensive over time due to resource declines, also fail as the system changes. Furthermore, existing metrics tend to be focused on the costs/benefits within an existing system over the lifetime of the infrastructure under question. In some cases, this is inherent in the metric, such as levelized cost of electricity (LCOE) for electricity generation. But even attempts to account for the costs and benefits within a given energy system, such as levelized avoided cost of electricity (LACE), are typically done within a static system.

The length of the mid-transition, which may be short compared with the lifetime of new infrastructure if we assume the mid-transition must be completed by 2050 and in many cases has not yet begun, introduces the need for new considerations given to the relative costs when lifetimes are shorter. For example, a power plant converted from coal to gas may be higher cost compared with the construction of a new combined cycle natural gas plant, but lower over a shortened lifetime of operation. Or the economics of deploying energy storage rather than new natural gas today in some regions may be favorable despite higher costs in today's calculation because of a future need to retire the gas plant before the end of its useful lifetime.

The mid-transition is likely to need three sets of heuristics: (1) those designed for the legacy system; (2) those designed for a fully zero-carbon system; and (3) those designed for the dynamic mid-transition period where the overall energy system still needs to deliver services, but in addition must create a transition to the zero carbon system while facing challenges of decadal dynamics as the zero-carbon system grows and the legacy system shrinks. Recognizing that each system will likely be operating in a way that accommodates the other for decades, and that such accommodations could be maladaptive in ways that might be locked in without careful attention to the differences between integrated carbon-emitting and zero carbon systems versus fully zero carbon systems, is critical. Explicitly designing and using fit-for-purpose mid-transition heuristics could be a valuable near-term contribution by the modeling and analysis community.

3.2 | System design

Fundamentally, at least for the supply side of the energy system, the mid-transition is a sociotechnical but highly material process of simultaneously deploying and retiring industrial systems like power plants, fueling stations, and vast networks of other infrastructure supporting highly diverse energy service provisioning. Implications for justice, equity, and the environment are in large part functions of system design, itself heavily inflected by political processes (Harrahill & Douglas, 2019; Healy & Barry, 2017). Although this review focuses on the United States and recognizes that political setting varies across nations, Mildenerger identifies the issue of “double representation,” where carbon incumbency receives policy advantages through representation in both left-leaning and right-leaning political coalitions, as a core feature of climate policy conflict in advanced economies broadly (Mildenerger, 2020).

During this transition, neither the older carbon-emitting system nor the new zero-carbon system will be fully optimized for its own needs, and the two systems will likely both need to adapt to accommodate the other. Importantly, this transition will be dynamic: a 30% zero-carbon system will likely behave very differently from a 70% zero-carbon system in its relationship with the carbon-emitting system, for example. Further, there will likely be significant justice and environmental considerations for managing times when both systems are working in ways that are somewhat hindered by the other, including operational issues (e.g., fossil fuel ramping), responses to market and ownership structures (e.g., solar curtailment in the context of electricity rates designed to encourage people to avoid using electricity during the day, when solar output is highest, due to historically high fuel costs during those periods), and competing public perceptions. These considerations highlight that just as fit-for-purpose technical heuristics are needed to evaluate progress toward the normative goal of eliminating greenhouse gas emissions, so too are indicators designed to accommodate mid- and post-transition dynamics needed to characterize progress toward normative social and justice goals (see, e.g., Cha, 2020; Healy & Barry, 2017; Thomas et al., 2019; Waisman et al., 2019). Developing theoretically grounded, usable, and valid metrics to evaluate social impacts and justice outcomes is a major and very challenging project of the socioenvironmental assessment community (Fortier et al., 2019; Grubert, 2018a; Hale et al., 2019) that is even more important in the context of major system dynamics. Decarbonization will create both acute and long-term challenges and opportunities with major implications for people's health, opportunities, and material well-being, grounded in the context of existing structural injustices that could be exacerbated without careful planning and the ability to quickly identify and correct problems.

The transitioning system will be characterized not just by the coexistence of zero carbon with carbon-emitting systems, but active reliance by maturing technologies on the existing system for support as they develop and gain experience at scale. That is, a system that is 50% zero carbon actively requires the rest of the system—the carbon-emitting system—to provide energy services, and if that carbon-emitting system is prematurely lost, there are likely to be dire consequences for society and energy users. This reliance is one reason that careful attention to phase-out is needed, potentially including incentives for workers to “stay on the line” operating carbon-intensive systems even well after it is clear they will be phased out.

Even within large and slow transitions, collapses can occur rapidly (Cohn, 2021) and with major consequences for those they affect (Snyder, 2018). Legacy infrastructure closures can occur essentially overnight, but deploying replacement infrastructure can take years given permitting, construction, and other timelines—a major motivation for closely coordinating phase-out and phase-in. Further, without active design and agreement on how the integrated and dynamic blended system will function, conflict over which critical energy functionalities each system needs to be able to provide is likely to emerge, with consequences for people. For example, if zero carbon system operators assume they do not need to solve the problem of clean firm power provision (Sepulveda et al., 2018) until 80% penetration, but profits decline sufficiently that operators of flexible natural gas-fired power plants depart at 50% zero carbon penetration, a crucial resource will have been lost.

Similarly, recognizing that emergent issues associated not only with learning (i.e., growing) but also with unlearning (i.e., shrinking) might occur, and planning for contingencies will be critical. For example, decarbonization studies commonly assume small amounts of natural gas will be available to the power sector to support the grid under relatively infrequent, challenging conditions, at prices and accessibility similar to what is observed today (E. Larson et al., 2020; Phadke et al., 2020; Williams et al., 2021, and see Committee on Climate Change, 2019) for a similar assumption in the UK context—but this assumption presumes that private extraction companies, pipeline operators, and other supply chain actors (that might not have a positive obligation to serve) continue to participate in the system despite clear messaging that there is not only no growth expected, but active decline, in these high capital intensity industries (McGlade et al., 2018). Implications of industry shrinkage for prices and markets are essentially not discussed. As such, attempts to secure participation under existing market structures could be highly inefficient and require significant subsidization of private sector profits.

We note that these issues are likely to manifest differently across countries with different planning, regulatory, and industry ownership contexts than the United States (Blondeel & Van de Graaf, 2018; Carter & McKenzie, 2020). The global nature of the fossil energy system, however, suggests that issues of unlearning in high capital intensity industries with meaningful international private sector participation, even for state-owned companies (de Graaff, 2012; Karl, 1999), will be widely experienced. Such dynamics are particularly relevant given that the existing system will likely continue to receive replacement-level investment (e.g., through repairs and equipment replacements), especially if there is not an explicit advance plan to disrupt steady-state replacement activities (see, e.g., Grubert, 2020b). A designed transition recognizing the dynamics not only of zero carbon system growth, but also carbon-emitting system decline, could enhance safety and welfare by anticipating these types of challenges and gathering the appropriate groups early enough to codesign workable solutions before crises emerge. Again, even fast decarbonization will likely take decades, allowing for some lead planning time.

The optimal length of the mid-transition period is typically determined based on the pace of emissions reductions required to constrain temperature increases, but a better understanding of the dynamics of the mid-transition and the potential for costs to change as a function of the length of the transition is an important input to policy making. For example, Way et al. suggest that as a result of the dynamics of learning processes through the transition, a faster transition can be less expensive than a slower one (Way et al., 2021). The point that infrastructure needs to be replaced as it ages, and that those replacements might be more or less compatible with a zero-carbon future (e.g., a natural gas turbine; a fossil hydrogen turbine that could convert to renewable hydrogen; or a fully decarbonized asset) depending on pacing, reinforces this observation. Full accounting of the costs from the interaction of the fossil and zero carbon systems during the mid-transition could further increase these cost savings.

3.3 | Resource constraints

Importantly in the context of designing the de-transition of high-hazard carbon-emitting energy systems, systems anticipating decline and closure will likely experience even more pronounced disinvestment than is already observed.

Markets are unlikely to function as they have in the past, and price shocks associated with unplanned and/or uncoordinated closures of large and capital-intensive facilities and infrastructures should likely be anticipated. Particularly given large outstanding liabilities associated with labor and environmental reclamation and remediation, careful attention will be necessary for managing multiple objectives in an increasingly resource-constrained context. Costly maintenance programs, specialist training, and worker recruitment for the carbon-emitting system are likely to decline over the next small number of decades, with major potential implications for safety, reliability, and other performance metrics that the integrated system might rely on. Mid-transition design should recognize and include the need to attract and retain skilled workers to operate the declining system as long as they are needed, while also recognizing the need to secure the future for workers in industries that are going to disappear, particularly given the extensive history of sudden bankruptcy and abandonment of worker and environmental obligations in the fossil transition to date (Macey & Salovaara, 2019). Simultaneously, labor requirements for phase-in of zero carbon systems are expected to be very large but often temporary, with potentially different skillsets, locations, and wage structures than are currently experienced by energy workers (Cha et al., 2021; Mayfield et al., 2021; Pai, Harrison, & Zeriffi, 2020). Training both short-term and long-term workers, and ensuring material security, safety, and equitable access will be major challenges of phase-in, just as they are for phase-out.

In addition to financial and labor constraints, energy systems are subject to material resource constraints. New systems, as with old systems, are resource constrained. During initial system buildout, zero-carbon systems could be constrained both by raw materials and by factory capacity due to the sheer rapidity of transition requirements. Such constraints can also give rise to oversupply and resulting market volatility, a dynamic that has been observed in the scale up of solar PV production which has been characterized by alternating periods of oversupply and scarcity (Bloomberg, 2020). Resource market volatility is not specific to zero carbon systems; rather, it is high growth rates that underpin the challenge.

Longer term, though, the transition from underground to aboveground resources (Mulvaney, 2017) means that the dominant constraint will likely be land with appropriate characteristics rather than a depletable fuel resource like coal, oil, or natural gas. As such, redeveloping the same sites with better technologies over time could actually improve productivity for some resources, in contrast to fossil fuel-based systems. Even still, this land-based resource constraint is relevant. Relatively low power density for flow resources like wind and solar as opposed to stock resources like fossil fuels (accumulated solar energy; Diaz-Maurin, 2016; L. M. Miller & Keith, 2018) means that powering a fully zero-carbon, electrified system will require many individual plants, all with siting processes and multicriteria non-GHG socioenvironmental impacts that need to be carefully evaluated to minimize cumulative harms (del Río & Burguillo, 2008; Grubert, 2021; Figure 2) and improve on the experience with fossil resources (Jenner & Lamadrid, 2013; Olszynski, 2014).

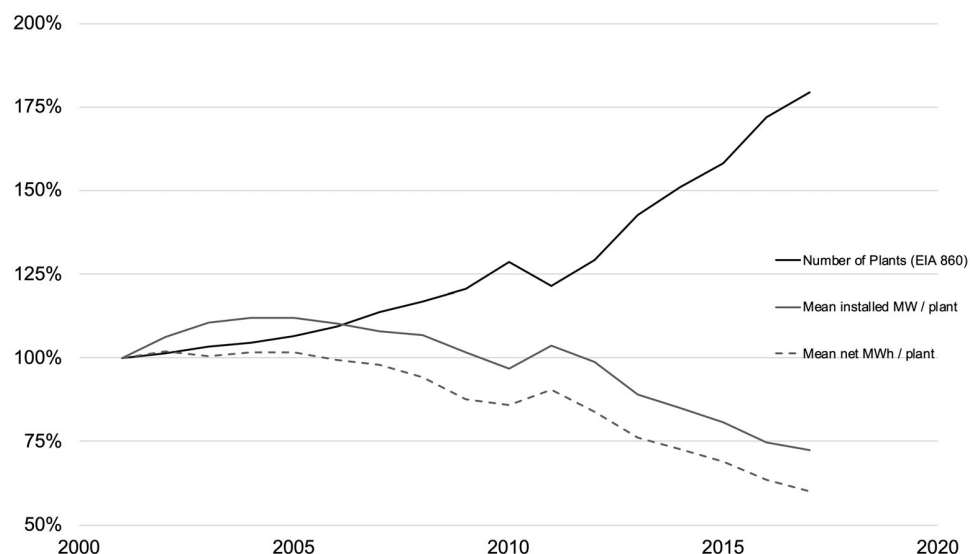


FIGURE 2 US power plants are growing smaller and more numerous over time, correlated with growth in renewable energy penetration. Indexed to 2001 = 100% of metric. Source: EIA 860

The pace of transition, mediated by social license and the confluence of potentially tens of thousands of siting processes, is relevant not only for climate but also because fossil fuels are depletable (Farrell & Brandt, 2006; Grubert, 2012; Höök & Tang, 2013; Patzek & Croft, 2010). Depending on carbon-based systems in the long-term, particularly if doing so requires high energy intensity activities like carbon capture, could result in the need for ongoing innovation in and development of the fossil fuel industry even as it is being phased out, representing major resource allocation conflicts. Further, oil extraction gets more climate intensive (and often more expensive) with oilfield age (Masnadi & Brandt, 2017), and the fossil industry is energy, capital, and emissions intensive (S. A. Miller & Grubert, 2021), with high requirements for technical expertise requiring large training infrastructures. Relatedly, building out zero operational carbon infrastructure can be emissions intensive depending on background contexts (Di Felice et al., 2018), so specific pathways matter.

4 | SOCIETAL CONTEXT OF THE MID-TRANSITION

The mid-transition will present numerous challenges beyond technical design and integration challenges, in many cases due to societal contexts like existing power structures, direct impact of policy-mediated transition on people, and mirrored impacts of people on technology. A status quo bias favors incumbents (Samuelson & Zeckhauser, 1988). As noted above, one major challenge for the mid-transition is that the carbon-based system is not being phased out because it does not work (although climate change and extreme events are increasingly obvious challenges to this perception), but because previously acceptable harms (largely, GHG emissions) are no longer acceptable because the environmental context, and environmental knowledge, has changed. There is no guarantee the future system is obviously better from an individual's perspective (see, e.g., [She et al., 2017] on people choosing to “wait and see” about battery electric vehicles), particularly given clear and present dangers like excessive heat that seem to emphasize the need to retain systems that have always been reliable in the past. As such, understanding the context of power, perception, and experiences people are likely to have is also crucial for understanding the mid-transition.

4.1 | Political power

Transition away from carbon-based systems requires destabilization of existing power structures (Haas & Sander, 2016) rather than the pure technological change that is more easily represented in models. Particularly given the size and power enjoyed by some of the major actors in the carbon based economy (Kenner & Heede, 2021), and their active efforts to slow or prevent rapid decarbonization transition (Černoch et al., 2021; Franta, 2021; Geels et al., 2017; Kenner & Heede, 2021; Mildenberger, 2020), phase-out is unlikely to happen on its own. Rather, it will likely require active and repeated political decisions in highly contested contexts, leveraging understanding of coalitions, feedbacks, and contexts just as for acceleration of the forward transition (C. A. Miller et al., 2015; Roberts et al., 2018).

4.2 | Public perception and experiences

Both decarbonization-oriented industrialization and deindustrialization could face significant challenges associated with the fact that both activities are intended to create national (and global) benefit at the expense of local harms, and that host and prospective host communities are likely to understand, and oppose, concrete and easily communicated negative impacts. Accusations of NIMBYism fail to recognize that there are often good reasons to oppose specific projects, even when people support transition in general—a phenomenon sometimes called the “social gap” (Batel & Devine-Wright, 2015; D. Bell et al., 2013; Devine-Wright, 2009; T. Measham et al., 2021; Sward et al., 2021). Particularly given the roles of trust (T. Measham et al., 2021), identity and deeply held values (S. E. Bell & York, 2010; Cha, 2020; Chan et al., 2016; Colvin, 2020; Colvin et al., 2015; Devine-Wright, 2009; Grubert, 2018b; Klain et al., 2017), and understanding that focusing on issues that are granted authority in decision contexts can be the expedient way to gain value-consistent outcomes (Fischhoff, 2013) in siting, social license, and transition processes generally, explicit and advance planning for transition that recognizes values and aims to create positive futures is crucial (Abraham, 2017; Grubert, 2017b; Haggerty et al., 2018; Snyder, 2018).

The perception that the existing system is still essentially functional, despite the serious local and global threats associated with ongoing use of fossil fuels and the increasing awareness that existing systems are not resilient to climate change and extreme weather (Busby et al., 2021; Guliasi, 2021; Malcolm et al., 2021; Wong-Parodi, 2020), poses additional inertial challenges associated with the extant carbon-based system. Problems during the mid-transition, including those that also affect carbon-based systems, could be blamed on the new entrants perceived as the reason the system is not as effective as it used to be—take, for example, the case of the Texas Freeze during Winter Storm Uri, when natural gas system failures in the face of extreme weather that lead to dangerous and widespread blackouts were instead publicly and authoritatively blamed on the wind system (Busby et al., 2021). Similarly, challenges with new technologies, like avian mortality from wind turbines (May et al., 2015), could have major and long-term implications for public perception and social license even if the problems are solved. Consider that compact fluorescent lightbulbs, introduced in the 1980s, faced major perceptual barriers due to early challenges whereby consumers did not value benefits (efficiency, lifetime) relative to losses of incandescent bulb characteristics like instantaneous lighting and low purchase prices (Menanteau & Lefebvre, 2000). As such, particularly early in the mid-transition, even rare missteps—let alone new and difficult-to-mitigate impacts, like the large land impacts of renewable energy systems that rely primarily on above-ground rather than below-ground resources (Mulvaney, 2017)—could be extremely challenging for technology deployments.

Early-stage deployment often suffers from challenges associated with immaturity that might not be permanent (Rosenberg, 1976), but performance challenges relative to alternatives—in this case, the pre-climate change fossil fuel-based energy system—could be meaningful barriers to successful normative decarbonization transition in a way that mid-transition design should account for. Especially because people often value losses more highly than gains (i.e., gain-loss asymmetry, or loss aversion) (Bateman et al., 2009; Horowitz & McConnell, 2002), and because gains associated with avoiding more severe future climate change are difficult to parse, even new technologies with significant benefits might be seriously hindered by perceived losses. For example, personal electric cars might be quieter, less polluting, cheaper to run, easier to charge at home, and safer than internal combustion engine vehicles, but charging times relative to filling up a vehicle at a gasoline station remain a major perceived barrier to acceptance (see Box 2).

Because people use energy directly, many of these technology transitions will be felt personally by people who will need to modify relationships to the energy system (Geels et al., 2017). Simultaneously, people's relationships to the energy system will in turn shape the energy system, as users interpret and participate in the mid-transition (Kline & Pinch, 1996). That is, just as the technical setting of the mid-transition will likely affect society, the social setting of the mid-transition will affect technologies. Beneficial electrification (Dennis, 2015; Williams et al., 2021) of currently fuel-based services like natural gas furnaces, natural gas stoves, and gasoline cars will have direct impacts on user experiences, likely with some advantages (e.g., lower indoor air pollution) accompanied by required behavioral changes and unfamiliarity that might be seen as a negative (see Box 2). These changes, directly integrated into people's lives, are social processes that might be felt as major impositions and injustices without care dedicated to how, and by whom, the systems are detransitioned (Hu, 2020; Itten et al., 2021). Misalignment with collective values and cultural models, particularly those typically excluded from “expert” narratives, can also pose challenges, including when groups self-select out of technical systems that they do not see as relevant, accessible, or appropriate for themselves (Tidwell & Tidwell, 2018). Although technological systems can impose structural boundaries, motivating emphasis on responsible

BOX 2 Why might the mid-transition be particularly challenging for new technologies?

Consider the case of electric cars: they are quiet, have low total cost of ownership relative to petroleum-based cars, and can be fueled at home. They reduce air pollution, and they require less maintenance than petroleum-based cars. Advances suggest that they could soon be cost competitive with petroleum-based cars even from a capital cost perspective. These benefits, however, occur in the context of wide acceptance of petroleum-based cars and the problems they create. As such, perceived disadvantages of EVs relative to the acceptable status quo are seen as additive problems, without the benefit of recognizing subtractive harms. Consider the situation where a society accustomed to EVs was transitioning to petroleum-based vehicles. Just as we now see concerns about fueling time, availability of fuel stations, and costs, EV users being asked to transition to petroleum-based cars might have major concerns about needing to travel to refuel, using highly flammable liquids, creating air pollution, noise, and maintenance cycles. For systems that are already widely accepted, incumbency is favored.

innovation (Stilgoe et al., 2013), people can also generate novel and potentially unexpected approaches to using technology that push these boundaries and contribute to feedbacks that make the mid-transition an intertwined socio/technical process (Kline & Pinch, 1996).

Simply planning how zero carbon systems will come to be without also planning for how carbon-based systems will be phased out is not adequate for major sociotechnical systems like energy. The mid-transition is a potentially decades-long process of achieving both goals, with familiarity and other forms of inertia strongly favoring preservation of the fossil system, especially given that high-impact, distressing events associated with the failure of industrialized systems in general to perform well under climate change could easily be blamed on the new, immature entrants that will likely have some major flaws.

Focusing on public “acceptance” of energy transitions can sometimes miss the point not only that publics are agents of energy transitions (Kline & Pinch, 1996), but also that public attitudes are nuanced and can be very well informed in contexts of general support for a transition but opposition to particular projects or processes (Sward et al., 2021). Just because a project provides something of value, like zero-carbon energy, does not mean that it performs well on all socioenvironmental criteria of interest—some of which are extremely important to people (Grubert, 2017b). The public participates in transition, sometimes explicitly as part of decision processes—a role that is increasingly incorporated (Komendantova et al., 2018; Ulibarri, 2019; Xavier et al., 2017)—and always as users, hosts, and constructors of technologies. Transitions can be extremely disruptive (Jacquet et al., 2018; Theodori, 2018), with ambivalence about mixed positive and negative impacts.

Notably, some of the most well developed literature on public response to energy transition in the United States focuses on response to the very recent industrialization associated with the rapid expansion of natural gas and oil production since about 2010 (Brasier et al., 2011; Jacquet, 2015; Jacquet et al., 2018; Junod et al., 2018; Theodori, 2012, 2018; Zanolco et al., 2020)—an important reminder that transitions are not linear, and also important societal context that some of the most visible recent transition has been fossil-based, with attendant impacts (T. G. Measham et al., 2015). US oil production represents an interesting transition case study also in the sense that one resource (conventional oil) has declined, while another (unconventional oil) has grown rapidly (Manfroni et al., 2021): although the consumer products are largely the same, this transition has been real and could be instructive. Similar social scientific attention to solar development is also emerging (Carlisle et al., 2014; Carlisle et al., 2015; Carlisle et al., 2016; E. C. Larson & Krannich, 2016; T. Measham et al., 2021; Tidwell & Tidwell, 2021), with recognition that public attitudes toward energy systems are not simplistically positive or negative based on GHG emissions profiles, nor static in the face of processes in which the public participates.

Practical design constraints, like how to manage which infrastructures are preserved as carbon-based systems shrink, also pose challenges. For example: fully electrifying personal transportation implies not only substantial build-out of charging infrastructure (The White House, 2021a), which will happen unevenly in space and time, but also a simultaneous and similarly uneven phase-out of gas stations (many of which have substantial environmental liabilities due to hydrocarbon spills and tanks), a major and increasingly urgent issue that has received little to no research or policy attention in the United States. Given the messaging challenges associated even with phase-out of coal for electricity, particularly related to jobs and local impacts in a relatively small industry (Bureau of Labor Statistics, 2021), inattention to processes likely to result in widespread job losses and environmental liabilities is both politically understandable and likely a grave mistake in the deeply political process of transition (Healy & Barry, 2017). The unplanned and unmanaged phase-out of coal, which is relatively easily substituted in ways that electricity users likely do not even notice, has resulted in widespread shedding of labor and environmental liabilities (Macey & Salovaara, 2019), long-term structural harm to host communities, and other challenges likely to be amplified in larger and more consumer-integrated fossil-based industries. A transition where gasoline stations make decisions to close independently, without design, could leave entire groups of people in very difficult situations, but forcing gas stations to remain open is not easily achieved under current regulatory structures. Careful design will be necessary to prevent the most vulnerable from bearing disproportionate costs both of increased cost of service associated with shrinking systems and of lack of service in general, across multiple consumer-facing carbon-based infrastructures. Conflict between public and private decision making on siting is also emerging for electric vehicle charging stations (Asensio et al., 2020; Globisch et al., 2019; Guo et al., 2016; She et al., 2017), suggesting that more centralized planning might be necessary to facilitate the transition period when neither gas stations nor EV chargers will be fully ubiquitous.

5 | CONCLUSION

The mid-transition will be characterized by climate and energy system non-stationarities. Failing to plan for the phase out of the carbon-producing energy system, while also planning to phase in the zero carbon system, could seriously

threaten this normative transition of decarbonization. Emphasizing justice and energy service provision, including via focus on providing for material needs, is likely to be core to a successful transition. One major finding of this review is that the mid-transition is not widely evaluated as a simultaneous process of addition and subtraction, starting from a failure to define and characterize the mid-transition period. Specifically, the mechanics of carbon phase out are poorly represented in the literature. As a side effect, this review almost certainly overlooks some key considerations on the technical and social context of the decarbonization transition, and we urge additional work focused explicitly on these issues at local through global scales. Meanwhile, we make several recommendations based on our evaluation of the current landscape.

Analytically, the mid-transition period should be better represented, starting with a definition and identification of the mid-transition period for different energy systems. Then, quantitative models (often granted high authority in decision processes) should explicitly account for phase-out and phase-in in ways that can be used to test various impacts of interest across multiple designed pathways, with careful attention to which services each system will be providing and whether there are sufficient incentives and/or requirements for those provisionings. For example, simply assuming for-profit companies that have historically participated in the energy system due to market incentives and expectations for stability or growth will continue to operate in qualitatively similar ways could be a major mistake. New heuristics should be developed for the mid-transition period that include the temporal dimension and allow for better comparisons between different options for resources in different transition pathways.

The role of governance and institutional structures could be particularly important to track, given their impact on how systems respond to change. Consider how unplanned fossil fuel phase-out might unfold for gasoline-fueled services, where individual service stations remain in business or exit the market based on profitability pressures, versus natural gas supply to residences, where utilities have an obligation to provide residential services that might conflict with practices like distribution system pruning. Further, in both cases, electrification (and subsequent reliance on electric utilities) could significantly change the regulatory context of service provision. Explicitly designing models to be updated based on shifting baselines and climate/energy dynamics relevant for decision support is also likely to be a fruitful area of inquiry (Joyce & Björklund, 2021).

From a visioning perspective, it will be crucial to design the mid-transition as a pathway to a post-transition world that fulfills needs and confers opportunities, shaped by participants during both planning and implementation. Mid-transition choices that result in dead ends, like replacement investments in capital infrastructure almost certain to be stranded by later emissions and other targets, should be extremely carefully evaluated, particularly given resource constraints. The mid-transition is likely to be painful in some ways, both due to learning (e.g., about new technologies and navigating the world under ongoing and dynamic climate change) and to maladaptations associated with two fundamentally different systems accommodating each other, and so ensuring that the vision of the future is clear and positive is likely to be important for success in this political process of change. One particular recommendation is to focus on ensuring material security for all, consistent not only with the goal of infrastructure systems to enhance health, safety, and welfare for all (ASCE, 2020) but also with observed pathways to public support for transition (Bergquist et al., 2020) and particularly under deindustrialization (Snyder, 2018).

Transition, and climate change, is concerning for people. In part, this is because of fears that we will lose things we need or value, like healthcare, job security, and a healthy future for generations to come. Ensuring that there is space to raise and act on these values and concerns in decision processes could help clarify what people want from a transition, while also avoiding situations where people correctly recognize that certain issues have more decision power than others, and that attacking those issues can be the only reasonable path to addressing other perceived challenges (Fischhoff, 2013). It is important to understand the technological needs for future energy systems. But also crucial for a successful mid-transition in the United States, and globally, will be understanding the role of power, agency, and politics in the social context of transitions expected to result in losses for some (Köhler et al., 2019; C. A. Miller et al., 2015).

ACKNOWLEDGMENTS

No specific funding was received for this work.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Emily Grubert: Conceptualization (lead); formal analysis (lead); visualization (lead); writing – original draft (lead); writing – review and editing (lead). **Sara Hastings-Simon:** Conceptualization (supporting); investigation (supporting); writing – original draft (supporting); writing – review and editing (supporting).

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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How to cite this article: Grubert, E., & Hastings-Simon, S. (2022). Designing the mid-transition: A review of medium-term challenges for coordinated decarbonization in the United States. *Wiley Interdisciplinary Reviews: Climate Change*, e768. <https://doi.org/10.1002/wcc.768>

STATE OF MICHIGAN
BEFORE THE MICHIGAN PUBLIC SERVICE COMMISSION

In the matter of the application of **DTE GAS COMPANY** for authority to increase its rates, amend its rate schedules and rules governing the distribution and supply of natural gas, and for miscellaneous accounting authority.

Case No. U-21291

ALJ Jonathan F. Thoits

PROOF OF SERVICE

I, Mark Templeton, certify that an electronic copy of the Updated Exhibit List and Official Exhibits FLO-1 to FLO-6 (Part 1 of 13) on Behalf of Frontline Organizations was served on the following on June 24, 2024.

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The statements above are true to the best of my knowledge, information, and belief.

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Date: June 24, 2024

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