Incorporating Health and Equity Metrics into the Minnesota Power 2021 Integrated Resource Plan

Prepared by PSE Healthy Energy on Behalf of
Fresh Energy, Minnesota Center for
Environmental Advocacy, and the Sierra Club

April 2022

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Funding

This report was funded by Fresh Energy, Minnesota Center for Environmental Advocacy, and the Sierra Club.

Acknowledgments

We would like to thank the many people who provided input, suggestions, and feedback on our analysis, including Ellen Anderson, Aaron Decker, Stephanie Fitzgerald, Barb Freese, James Gignac, Chelsea Hotaling, Evan Mullholand, Bret Pence, Isabel Ricker, Andrew Slade, Anna Sommer, Lora Wedge, Joy Wiecks, Laurie Williams, Jenna Yeakle, and many others. Any errors or omissions remain our own.

About PSE Healthy Energy

Physicians, Scientists, and Engineers for Healthy Energy (PSE Healthy Energy) is a multidisciplinary, nonprofit research institute dedicated to supplying evidence-based scientific and technical information on the public health, environmental, and climate dimensions of energy production and use. We put our mission into practice by integrating scientific understanding across multiple disciplines, including engineering, environmental science, and public health.

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About the Authors

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Executive Summary

Minnesota Power's 2021 Integrated Resource Plan (MP's 2021 Plan) holds implications for public health, affordability, and equity across its territory, the state, and the region. Here, we develop a framework to analyze the public health and equity dimensions of MP's 2021 Plan, specifically looking at the two coal plants (Boswell Energy Center and Milton R. Young), biomass plant (Hibbard Energy Center), gas peaker (Laskin) and proposed natural gas combined cycle facility (Nemadji Trail Energy Center, or NTEC) in Minnesota Power's electricity generation portfolio. We find that the ongoing operation of coal plants to supply electricity to Minnesota Power customers is associated with dozens of mortalities from 2021-2035, that the construction and use of NTEC is associated with upstream methane emissions that greatly increase its potential climate impacts, and that proposed residential energy efficiency levels lag behind for the low-income households who could most benefit from the affordability gains offered by access to efficiency. Increased adoption of renewable energy and energy efficiency, including targeted programs for low-income households, could help mitigate these public health and equity impacts by increasing affordability and enabling the earlier retirement of coal units and reducing the need to rely on expanded natural gas electricity generation.

Specifically, we estimate that the Boswell plant will contribute 47 $PM_{2.5}$-related mortalities from 2021-2035. These health impacts fall disproportionately on Native populations by a factor of three. The plant is also located in a disproportionately low-income community with high cumulative socioeconomic burdens. Retiring Boswell Unit 3 by 2025 and Unit 4 by 2030 would save approximately 17-19 lives, reduce adverse health impacts by approximately $200 million, reduce on-site disposal of 2,260 tons of waste, and save approximately 2.6 billion gallons of water.

Although located in North Dakota, Milton R. Young's emissions have significant health impacts in Minnesota as well as across the whole region. Milton R. Young's emission rates are higher than Boswell's for most pollutants. The portion of electricity Minnesota Power has committed to purchase from this plant is expected to cause roughly 3.5 mortalities per year through 2025, when Minnesota Power's contract expires. The decision in MP's 2021 Plan to reduce reliance on this plant may contribute to lower emissions if there are no other electricity off-takers, which would have great public health benefits across the region, but residents will not see these benefits if the plant gets locked into ongoing operation through new long-term contracts.

The Hibbard Energy Center, which burns biomass and some coal, also has significant public health impacts. Hibbard is the most urban power plant of those analyzed and the nearby populations are disproportionately low-income and face high cumulative socioeconomic burdens. The impacts of this plant are uncertain in the future due to a change in ownership of the attached paper mill, which has historically used steam from the facility. However, ongoing use of Hibbard in MP's 2021 Plan means ongoing air pollutant emissions in this community, affecting those nearby and across the region.

The proposed NTEC facility is located in a relatively low-income community with a higher number of people living nearby than any other facility analyzed except Hibbard. Moreover, the carbon dioxide emissions associated with future gas combustion at this facility only represent about half of the greenhouse gas impacts of this plant in the near term: inclusion of upstream fugitive methane emissions associated with gas production, processing, and transmission suggests that the total climate impacts of the facility will be nearly double the direct CO_2 emissions over a 20-year timeframe.

Energy cost burdens within Minnesota Power territory are substantially higher in low-income census tracts with a high share of renters and a high share of Black residents. These low-income areas and populations can benefit from energy-saving measures to help reduce energy cost burden inequities. Historically, Minnesota Power's energy efficiency investments in low-income communities have averaged 20 percent of total residential efficiency investments and projected low-income energy savings are only 13 percent of total projected residential energy savings. These numbers are not proportional to the share of the low- and moderate-income population in Minnesota Power territory, which we estimate to be around 30 percent of the total population. To achieve a meaningful reduction in energy cost burdens within its territory, Minnesota Power will need to adopt its Very High efficiency scenario with a provision that at least one third of all projected energy savings are attained in low-income households. We estimate that this will more than quadruple the number of low-income households adopting energy-saving and bill-reducing measures annually. In addition, Minnesota Power should invest significantly more in expanding rooftop and community solar programs that provide affordable electricity to low- and moderate-income households.

1. Introduction

In the face of climate change and under statewide targets to reduce greenhouse gas emissions, Minnesota's utilities are planning significant changes to their electricity generation portfolios in the coming years. The resources used in these portfolios, and the pathways utilities take to add these resources, hold implications far beyond resource adequacy and greenhouse gas emissions. Existing power plants produce health-damaging air pollutants that have impacts on communities both near these plants, across the state, and even beyond its borders. The energy resources selected—as well as their costs and distribution—hold implications for energy affordability, choice, and resilience, which may be of particular concern to low-income households, populations of color, and others that have historically faced higher energy cost burdens than their wealthier counterparts.[1] Utility integrated resource plans (IRPs), which are used to identify customer demand and plan accordingly for the requisite energy and capacity resource procurements, can therefore have a direct impact on public health outcomes, affordability, and equity. Here, we take a careful look at Minnesota Power's 2021 proposed Integrated Resource Plan[2] (hereafter, MP's 2021 Plan) along public health, affordability, and equity dimensions, highlighting the potential impacts and benefits of the Plan's energy and capacity procurement decisions.

Fossil fuel and biomass use in the power sector can have a range of health and environmental impacts through pollution of the air, water, and soil. Combustion of coal, gas, oil, and biomass[3] produces both greenhouse gases and hazardous and criteria air pollutants, such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter, and heavy metals. These pollutant levels vary with both fuel type and environmental controls at any given facility. Power-sector combustion results in both the emission of *primary air pollutants*, i.e., pollutants that are emitted directly from the plant's combustion, and the creation of *secondary air pollutants*, i.e., pollutants that form in the atmosphere downwind from the plant. For example, NO_x and SO_x emissions from a plant can both react chemically in the atmosphere to form fine particulate matter ($PM_{2.5}$), while NO_x emissions can also react with volatile organic compounds (VOCs) to form ozone.[4] Exposure to primary or secondary air pollutants can lead to a wide range of respiratory and cardiovascular health impacts, from asthma attacks to heart attacks and premature death.[5,6,7] Air pollution from power plants can lead to health impacts hundreds of

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[1] Drehobl, A. et al. (2020). How High Are Household Energy Burdens? An Assessment of National and Metropolitan Burden Across the United States. *American Council for an Energy-Efficient Economy.*

[2] Minnesota Power (2021). 2021 Integrate Resource Plan. *Docket No. E015/RP-21-33.*

[3] Depending on the biomass source, some of the greenhouse gas emissions of biomass combustion may be mitigated when the fuel is analyzed on a full-lifecycle basis.

[4] Minnesota Pollution Control Agency. "Volatile Organic Compounds (VOCs)." Accessed April 2022.

[5] Murray, C. J., et al. (2020). Global Burden of 87 Risk Factors in 204 Countries and Territories, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10258), 1223-1249.

[6] Vohra, K., et al. (2021). Global Mortality from Outdoor Fine Particle Pollution Generated by Fossil Fuel Combustion: Results from GEOS-Chem. *Environmental Research*, *195*, 110754.

[7] Thurston, G. D., et al. (2016). Ischemic Heart Disease Mortality and Long-term Exposure to Source-related Components of US Fine Particle Air Pollution. *Environmental Health Perspectives*, *124*(6), 785-794

miles downwind from the emission source;[8] however, the impacts tend to be highest per capita nearest to and downwind from the power plant stacks. Disposal of coal ash in impoundments can result in heavy metal contamination to water and soil, posing health risks to nearby communities.[9] Living near power plants is associated with adverse health outcomes, such as premature births[10] and asthma,[11] and sensitive populations such as the young, the elderly, and those with underlying conditions are most at risk. Moreover, power plants are often disproportionately located in low-income communities,[12] as well as places with high cumulative environmental health burdens from numerous sources,[13] raising equity concerns. The reduction of emissions and waste from these plants can therefore have potential health benefits for both communities living nearby and across a broad geographical region.

In addition to pollution burdens, many households also struggle with affordability and energy cost burdens associated with paying their energy bills. These burdens are often highest for low-income households and communities of color[14]—the same communities that often lag behind in access to solar[15,16] and other clean energy resources such as energy efficiency.[17] Energy efficiency can help lower utility bills, and residential solar can both reduce bills and provide bill stability. However, those without access to capital, renters, linguistically isolated populations, and others often face barriers to accessing these resources without programs and financing targeted to reach them.

The energy resource choices made within the IRP process hold implications for both energy affordability and the public health burdens and benefits associated with these resources. The choice to operate certain power plants, for example, has direct and calculable public health impacts. The overall costs of any plan have implications for energy affordability because these costs are typically passed on to ratepayers through subsequent cost recovery proceedings. Furthermore, the choice to include specific resources—such as energy efficiency, residential demand response, or rooftop solar—can have affordability implications. For example, the inclusion of residential energy efficiency and low-income energy efficiency resources in IRPs

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[8] National Research Council. (2010). Global Sources of Local Pollution: An Assessment of Long-range Transport of Key Air Pollutants to and from the United States. *National Academies Press.*

[9] Environmental Integrity Project. (2020). Ashtracker.

[10] Casey, J.A., et al. (2018). Increase in Fertility Following Coal and Oil Power Plant Retirements in California. *Environmental Health* 17(1), 1-10.

[11] Casey, J.A., et al. (2020) Improved Asthma Outcomes Observed in the Vicinity of Coal Power Plant Retirement, Retrofit and Conversion to Natural Gas. *Nature Energy* 5(5), 398-408.

[12] U.S. Environmental Protection Agency. (2021). Power Plants and Neighboring Communities Graphs.

[13] Krieger, E.M. et al. (2016). A Framework for Siting and Dispatch of Emerging Energy Resources to Realize Environmental and Health Benefits: Case Study on Peaker Power Plant Displacement. *Energy Policy* 96, 302-313.

[14] Drehobl, A. et al. (2020). How High Are Household Energy Burdens? An Assessment of National and Metropolitan Burden Across the United States. *American Council for an Energy-Efficient Economy.*

[15] Sunter, D. et al. (2019). Disparities in Rooftop Photovoltaics Deployment in the United States by Race and Ethnicity. *Nature Sustainability* 2(1), 71-76.

[16] Lukanov, B.R. and E.M. Krieger. (2019). Distributed Solar and Environmental Justice: Exploring the Demographic and Socio-Economic Trends of Residential PV Adoption in California. *Energy Policy* 134, 110935.

[17] Reames, T.G. (2016). Targeting Energy Justice: Exploring Spatial, Racial/Ethnic and Socioeconomic Disparities in Urban Residential Heating Energy Efficiency. *Energy Policy* 97, 549-558.

can open the door for these energy efficiency programs to be addressed in other proceedings. Even though the exclusion of energy efficiency resources in IRP planning would not preclude other proceedings from addressing efficiency, such an approach might result in an over-build of capacity resources, resulting in excess costs that may get passed on to ratepayers.

Minnesota Power's electricity supply by the end of 2020 included 50 percent renewables—largely wind and hydropower and a small amount of solar and biomass—with most of the rest supplied by coal and modest contributions from gas.[18] Currently, the combustion power plants in Minnesota Power's generation mix includes five fossil fuel electricity-generating units—three coal units (Boswell Units 3 and 4 in Cohasset, Minnesota and Milton R. Young 2 in Center, North Dakota), one biomass-and-coal plant (Hibbard Energy Center in Duluth, Minnesota) and a natural gas peaking plant (Laskin Energy Center in Hoyt Lakes, Minnesota). Minnesota Power owns 100 percent of Boswell 3 (350 megawatts (MW)) and 80 percent of Boswell 4 (582 MW); 20 percent of Boswell 4 is owned by WPPI Energy, a Wisconsin public power provider. Minnesota Power does not own the 439 MW Milton R. Young plant but has historically purchased approximately half of the electricity generated at the plant. Minnesota Power has been phasing down this contract since 2014 and starting in 2026 will not purchase output from Young 2. Minnesota Power owns both the Hibbard and Laskin plants. Hibbard is a 47 MW facility that has historically burned both wood/paper waste and, to a lesser extent, coal. Until recently, Hibbard provided large quantities of steam to the Verso Duluth Paper Mill in addition to electricity generation. Laskin is a 99 MW facility that was converted from coal to natural gas in 2015.[19]

Under MP's 2021 Plan, the utility's fuel mix shifts away from coal towards renewable energy and gas between 2021-2035, with additional demand reduction being met through ongoing energy efficiency savings. The plan relies, in part, on construction of a new natural gas plant just across the border in Wisconsin—the Nemadji Trail Energy Center (NTEC). In MP's 2021 Plan, Minnesota Power analyzes several scenarios, focusing on a central case with mid-range environmental costs and carbon dioxide (CO_2) prices. Additional scenarios test the sensitivity of environmental costs, the retirement year of the coal-fired Boswell Energy Center, various levels of energy efficiency and fuel prices, alternative energy resources, and other variables.

In this analysis, we introduce a framework to incorporate public health and equity metrics into MP's 2021 Plan. We focus primarily on MP's recommended 2021 Plan but additionally address (1) the potential early retirement of the Boswell plant, (2) the development of NTEC, and (3) the benefits of additional resources such as efficiency and rooftop solar. Under Minnesota Statute 216B.2422, the Public Utilities Commission "shall, to the extent practicable, quantify and establish a range of environmental costs associated with each method of electricity generation. A utility shall use the values established by the Commission in conjunction with other external factors, including socioeconomic costs, when evaluating and selecting resource options in all proceedings before the Commission, including resource plan and certificate of

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[18] Allete Inc. (2020). Minnesota Power Reaches 50 Percent Renewable Energy Milestone to Lead Minnesota Utilities.

[19] Minnesota Power (2021). 2021 Integrate Resource Plan. *Docket No. E015/RP-21-33.*

need proceedings."[20] To date, this approach has largely entailed incorporating a carbon price into IRPs and the Commission has adopted a $/ton value for criteria pollutant emissions. The methods we introduce here provide a more extensive approach to addressing these environmental and socioeconomic costs, both for the MP's 2021 Plan and for similar IRPs across the state. Our results are not directly comparable to the externality approach used by the Commission, because the inputs, models, and health and environmental factors considered differ. Additionally, the externality factors used by the Commission aggregate information across all power plants in Minnesota rather than accounting for plants individually.

In the following sections we describe our methodology (**Section 2**) and then discuss our findings (**Section 3**), including how specific IRP decisions relate to (1) populations living near power plants, (2) public health impacts of coal plant emissions and hazards of coal ash waste, (3) public health impacts of the biomass plant Hibbard, (4) environmental health and climate concerns associated with gas plants, including the proposed NTEC facility, and (5) equitable access to energy and energy affordability. We summarize our key findings in **Section 4**.

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[20] Minnesota Legislature. (2021). 216B.2422 Resource Planning; Renewable Energy.

2. Methodology

We approached our analysis by first reaching out to community-based organizations and non-profit organizations in the Minnesota Power territory to conduct informal interviews and identify priorities and concerns related to power generation in the region. We used these conversations to inform our analytical approach. Below, we describe the methods by which we (1) analyze populations living near power plants serving Minnesota Power, (2) model the $PM_{2.5}$-related morbidity and mortality associated with power plant emissions, (3) assess environmental hazards (such as coal ash) not included in our air pollutant analysis, (4) analyze lifecycle greenhouse gas implications of gas combustion if NTEC is constructed, and (5) address equitable energy access and energy affordability.

2.1 Equity Screening and Demographics

While power plant emissions have health impacts over broad regions, these emissions typically have higher health impacts *per capita* on populations living nearby and downwind from power plants. Nearby populations may also be exposed to additional environmental health stressors beyond power plant stacks (e.g., on-site waste disposal, industrial equipment operation). To assess who may face increased risks from living next to power plants, we performed an equity screening analysis on populations living within one mile and three miles of each facility. The EPA has set a precedent for this approach in its Power Plants and Neighboring Communities screening tool, used to identify environmental justice concerns for populations living in proximity to power plants.[21] The Power Plants and Neighboring Communities tool reports socioeconomic and environmental burden indicators from its environmental justice screening tool EJScreen 1.0.[22] These indicators are reported both as absolute values (e.g., the percent of low-income households) and as percentiles (e.g., how a given location compares to census tracts across the state; for example, ranking at the 70th percentile for low-income populations would mean a region had more low-income households than 70 percent of census tracts statewide).

Both the Power Plants and Neighboring Communities tool and EJScreen 1.0 are somewhat limited in that they report indicators either *individually*, or in aggregation, i.e., by combining non-White population indicators, low-income population indicators, and a single environmental indicator. However, the EJScreen 1.0 tool itself includes six demographic indicators and 12 environmental indicators. Other environmental justice screening tools, such as CalEnviroScreen,[23] combine indicators together to identify locations with high *cumulative* socioeconomic burdens, high *cumulative* environmental burdens, and high *cumulative* socioeconomic and

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[21] U.S. Environmental Protection Agency. (2021). Power Plants and Neighboring Communities.

[22] U.S. Environmental Protection Agency. (2021). EJSCREEN: Environmental Justice Screening and Mapping Tool. Note: EPA updated EJScreen to version 2.0 in 2022. The data used here are from EJScreen 1.0.

[23] California Office of Environmental Health Hazard Assessment. (2022). CalEnviroScreen 4.0.

environmental burdens typically contribute to increased vulnerability to additional environmental stressors, meaning that these populations have more adverse health outcomes when exposed to the same pollutants than other populations. Such combined indices can also indicate where populations face disproportionate shares of legacy pollution, and where interventions to reduce pollution may be particularly valuable.

Therefore, we created a Demographic Index based on the six EJScreen 1.0 demographic indicators—populations of color, under age 5, over age 64, low-income, linguistically isolated, and low educational attainment populations.[24] For each census tract, we averaged the *state percentile* value for each of these six indicators. We created a Demographic Index by re-ranking these integrated scores for each census tract in the state and calculating the percentile value for this new index. We conducted a similar analysis using the EJScreen environmental indicators but found that these did not provide significant variation for census tracts within the Minnesota Power territory, and so omitted it from this analysis. EJScreen indicators tend to reflect environmental pollution burdens characteristic of urban areas, such as traffic proximity, but not those that might be characteristic of rural areas, such as pesticide use,[25] resulting in a better characterization of urban pollution concerns but not rural concerns. We also note that the Census data underlying EJScreen data may be less accurate, leading to additional uncertainties for our findings in rural areas.

We used EJScreen to calculate the value for each demographic indicator for both a one-mile and three-mile region around each power plant. Following the methods above, we calculated the Demographic Index for each of the existing fossil fuel facilities, as well as the proposed NTEC plant. We omitted Milton R. Young from our analysis because a very limited population lives within close proximity to this facility.

2.2 Power Plant Air Pollutant Health Impact Modeling

Fossil fuel and biomass combustion at power plants emits hazardous and criteria air pollutants. The emitted pollutants can both cause direct public health impacts and can transform chemically or physically in the atmosphere to form secondary pollutants, which can also have public health impacts. The majority of these public health impacts are associated with $PM_{2.5}$, which is both emitted directly from power plant stacks and formed as a secondary pollutant from NO_x, SO_2, and volatile organic compounds (VOCs). There are widely accepted methods to model $PM_{2.5}$ in the atmosphere and extensive epidemiological evidence linking $PM_{2.5}$ exposure to health impacts, inclusive of cardiovascular and respiratory impacts and premature death.[26,27,28] Here, we use two models to calculate the morbidity and mortality

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[24] See: U.S. Environmental Protection Agency. (2022). Overview of Demographic Indicators in EJScreen.

[25] For comparison, pesticide exposure *is* included in CalEnviroScreen.

[26] Dockery, D. et al. (1993). An Association Between Air Pollution and Mortality in Six US Cities. *New England Journal of Medicine*, *329*(24), 1753-1759.

[27] Krewski, D., et al. (2009). Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. *Res Rep Health Eff Inst.* (140), 5-114; discussion 115-136.

[28] Lepeule, J., Laden, F., Dockery, D., & Schwartz, J. (2012). Chronic Exposure to Fine Particles and Mortality: An Extended

impacts of $PM_{2.5}$-related power plant emissions under MP's 2021 Plan. As noted previously, NO_x and VOCs may chemically react in the atmosphere to form ozone, and ozone as well as other pollutants emitted from power plant stacks can have health impacts. However, the health impacts of pollutants other than $PM_{2.5}$ are more challenging to model and typically have a lower total impact than $PM_{2.5}$.[29,30] As such, we focus on $PM_{2.5}$, but suggest that our results are likely an *underestimate* of the actual health impacts of these plants given the emission and secondary formation of these other pollutants.

To assess power plant impacts, we first characterized pollutant emissions at each power plant serving Minnesota Power to create emission factors for each plant; second, we applied these emission factors to the projected generation under MP's 2021 Plan; and third, we modeled the cumulative health impacts of each fossil plant in MP's 2021 Plan using the U.S. Environmental Protection Agency's (EPA) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)[31] and the peer-reviewed Intervention Model for Air Pollution Tool (InMAP).[32,33,34]

Characterizing air pollutant emissions. As discussed earlier, four coal-, biomass-, and gas-fired power plants currently serve Minnesota Power: Boswell (coal), Milton R. Young (coal), Laskin (gas), and Hibbard (biomass and coal). At times, Minnesota Power purchases additional power from the Midcontinent System Operator (MISO), which we do not directly address here but the emissions from which should be considered in future analyses. We acquired data on electricity generation (megawatt-hours, MWh) and SO_2 and NO_x emissions from each facility from the EPA's Air Markets Program Database (AMPD),[35] which reports hourly emissions from power plant stacks recorded using continuous emissions monitoring systems. Coal VOC emissions are calculated using the low-end emission factor estimate for coal from Peng et al.,[36] who suggested application of an additional 65 percent emission reduction factor from an additional air pollution control device to provide a conservative emissions estimate. Natural gas $PM_{2.5}$ emissions were calculated using the AP-42 emission factor from the EPA's eGRID resource.[37] Gas VOC emissions were calculated using EPA emission factors.[38] We note that VOCs

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Follow-up of the Harvard Six Cities Study from 1974 to 2009. *Environmental Health Perspectives*, *120*(7), 965-970.

[29] Lelieveld, J., et al. (2015). The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale. *Nature*, 525(7569), 367-371.

[30] Murray, C. et al. (2020). Global Burden of 87 Risk Factors in 204 Countries and Territories, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10258), 1223-1249.

[31] U.S. Environmental Protection Agency. (2021). CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA).

[32] Tessum, C. W., et al. (2017). InMAP: A Model for Air Pollution Interventions. *PloS One*, 12(4), e0176131.

[33] Thakrar, S. K., et al. (2020). Reducing Mortality from Air Pollution in the United States by Targeting Specific Emission Sources. *Environmental Science & Technology Letters*, *7*(9), 639-645.

[34] Paolella, D. A., et al. (2018). Effect of Model Spatial Resolution on Estimates of Fine Particulate Matter Exposure and Exposure Disparities in the United States. *Environmental Science & Technology Letters*, *5*(7), 436-441.

[35] U.S. Environmental Protection Agency. (2021). Air Markets Program Data.

[36] Peng, Y., et al. (2021). VOC Emissions of Coal-fired Power Plants in China Based on Life Cycle Assessment Method. *Fuel*, *292*, 120325.

[37] U.S. Environmental Protection Agency. (2016). Estimating Particulate Matter Emissions for eGRID. Table 2.

[38] U.S. Environmental Protection Agency. (2020). Natural Gas Combustion.

are not the primary driver of $PM_{2.5}$ formation from these power plant stacks, and using a standardized emission factor should not greatly affect our estimates. Primary $PM_{2.5}$ emissions for Boswell Units 3 and 4 were calculated using emission factors derived from Minnesota Pollution Control Agency (MPCA)[39] data and $PM_{2.5}$ for Milton R. Young from the EPA's eGRID.[40] For each of the pollutants reported in the AMPD database, pollutant emission factors (tons pollutant/MWh) were calculated based on average generation and emissions from 2018-2020. For Hibbard, a biomass and coal-burning facility, emission factors for $PM_{2.5}$, NO_x, SO_x, and VOCs were derived from the MPCA's Permitted Facility Air Emissions Data tool.[41]

Calculating scenario emissions. We applied the above emission factors to calculate the projected annual emissions from each power plant under MP's 2021 Plan. To do so, we multiplied the emission factors (tons/MWh) for each pollutant by the estimated generation (MWh) for each power plant—or, in the case of Boswell and Laskin, for individual units (3 and 4 for Boswell, 1 and 2 for Laskin)—for every year of operation from 2021-2035.

Air pollutant models. We used two reduced-form models to estimate $PM_{2.5}$-related health impacts. The EPA's COBRA model is widely used to calculate the public health benefits and impacts of emission changes.[42] Inputs into the COBRA model include pollutant emissions (in this case, $PM_{2.5}$, NO_x, SO_2, VOCs), facility characteristics (e.g. stack height), and location (on a county basis). COBRA calculates how primary and secondary $PM_{2.5}$ associated with these emissions affects ambient (i.e., outdoor) $PM_{2.5}$ concentrations, and uses a concentration-response function to calculate the public health impacts associated with the change in $PM_{2.5}$ pollution. COBRA uses two different epidemiological models to characterize some of the public health endpoints of $PM_{2.5}$, resulting in a low and a high estimate. These impacts are reported both by health-endpoint incidences (e.g. asthma exacerbations) and by cost ($), which is calculated by assigning a monetary value to each health outcome. COBRA reports the spatial impacts of $PM_{2.5}$ on a county basis for the entire US.[43]

InMAP[44] is an independent peer-reviewed air quality model which uses similar inputs to COBRA combined with pre-processed chemical and meteorological information to calculate the marginal impacts of changes in emissions on ambient $PM_{2.5}$ concentrations. Here, we used InMAP in addition to COBRA because, while COBRA reports more extensive information on health outcomes, InMAP reports results at a much higher spatial granularity than COBRA (up to 1km resolution). Therefore, InMAP enables us to better identify whether certain populations

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[39] Minnesota Pollution Control Agency. (2019). Permitted Facility Air Emissions Data.

[40] U.S. Environmental Protection Agency. (2016). Estimating Particulate Matter Emissions for eGRID. Table 2.

[41] Minnesota Pollution Control Agency. (2019). Permitted Facility Air Emissions Data.

[42] U.S. Environmental Protection Agency. (2021). Publications that Cite EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.

[43] U.S. Environmental Protection Agency. (2021). CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA).

[44] Tessum, C. W., et al. (2017). InMAP: A Model for Air Pollution Interventions. *PloS One*, 12(4), e0176131.

are disproportionately affected by a given pollution source and provides the racial demographics of the affected populations.

InMAP and COBRA represent atmospheric chemistry and physics differently and there were also differences in model resolution, concentration-response function, and underlying demographic data. Thus, while the 2021 *total* $PM_{2.5}$-mortality estimates from InMAP were similar to COBRA estimates they were not exactly the same. The total mortality estimates from InMAP were closer to the low mortality estimates from COBRA, because the underlying epidemiological model that we used in InMAP was more similar to the model used for the COBRA "low" estimate. Additionally, the population data used in InMAP is older than COBRA, likely contributing to lower mortality values. As a result, the InMmAP results are likely an underestimate of total $PM_{2.5}$ mortality, compared to COBRA. We use the InMAP data to better understand the distributional impacts of these power plants, and which populations may be most burdened by this pollution, but rely more heavily on the COBRA data for estimating total impacts in the previous sections.

2.3 Power Plant Environmental Hazards

In addition to air pollutant emissions, fossil fuel power plants pose additional environmental health risks to the surrounding population. For example, coal ash waste is typically disposed of in impoundments, which may be structurally unsound and lead to local groundwater contamination. Water is typically used to cool thermal generating stations like coal and gas plants and may be returned in degraded form to the source or consumed on site. For power plants with available data, we therefore identified the coal ash waste from each site, aggregated data on groundwater contamination near coal ash impoundments, calculated water use, and estimated the annual coal ash disposed and water used by these plants under MP's 2021 Plan.

We retrieved on-site and off-site disposal of coal ash waste for Boswell and Milton R. Young from the EPA's Toxic Release Inventory (TRI).[45] In addition to total tons of waste disposed on- and off-site, TRI reports the mass of specific pollutants of concern, such as heavy metals. We used historic generation data from EPA's AMPD[46] database to calculate the tons of waste per MWh of electricity generation from each site and used these factors to calculate the projected waste produced under MP's 2021 plan. In addition, we reviewed coal ash impoundment structural integrity reports,[47,48] pollutant exceedances at groundwater monitoring wells at each site,[49] and federal environmental regulation violations reported through TRI. These additional

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[45] U.S. Environmental Protection Agency. (2021). Toxic Release Inventory (TRI) Program.

[46] U.S. Environmental Protection Agency. (2021). Air Markets Program Data.

[47] AMEC Earth & Environmental Inc. (2010). Report of Geotechnical Assessment of Coal Combustion Surface Impoundments Minnesota Power Boswell Energy Center, Cohasset, MN. AMEC Project No. 3-2106-0174.0300. Prepared for the U.S. Environmental Protection Agency.

[48] Minnesota Power. (2022). Boswell.

[49] Environmental Integrity Project. (2020). Ashtracker.

measures give insight into which plants may pose additional environmental health hazards. Finally, we aggregated cooling water data from the U.S. Energy Information Administration's Electricity Data Browser,[50] and calculated the water used per MWh of generation for each facility. We used 2019 waste data and 2020 water data to assess both the hazards posed by these facilities—including in the context of nearby populations—and the cumulative waste disposal and water use projected under MP's 2021 Plan.

2.4 Equitable Energy Access

Residential energy consumption data are not readily available at granular geographic scales conducive to detailed spatial and demographic analysis. To estimate average household energy consumption by census tract, we use a linear regression model that simultaneously approximates energy consumption by fuel type (propane, gas, electricity, wood), and end use (space heating, space cooling, water heating, and appliances) based on a variety of geographic, housing, demographic, and climate characteristics. We generate these estimates using previously developed models[51,52] with a combination of predictive variables extracted from the most recent 2015 Residential Energy Consumption Survey (RECS)[53] and the 2015-2019 American Community Survey.[54] We use this output, supplemented with the number of households in each census tract within Minnesota Power territory, to develop a weighting factor for each tract's share of Minnesota Power's residential electricity demand as well as each tract's share of statewide energy consumption for other fuels such as propane and gas. As Minnesota Power's service area boundaries do not neatly align with census tract borders, we derived the number of people within each tract living in the Minnesota Power territory using a block-weighted geographic apportionment method. This involved taking the intersection of the Minnesota Power territory and census block centroids and allocating the entire block's population to the service area if the centroid fell within its boundaries. Block population totals were then aggregated to determine what proportion of each tract is served by Minnesota Power.

To characterize residential energy cost burdens, we multiplied our census tract-level energy consumption estimates by Minnesota Power's 2019 electricity prices and the 2019 Energy Information Administration's Minnesota prices for other fuels[55] to estimate census tract-level energy expenditures. Average household energy cost burden was then calculated for each census tract by dividing the average household energy expenditures by the census tract median household income.

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[50] U.S. Energy Information Administration (2022). Electricity Data Browser.

[51] Min, J., et al. (2010). A High-Resolution Statistical Model of Residential Energy End Use Characteristics for the United States. *Journal of Industrial Ecology*, *14*(5), 791-807.

[52] Jones, C., and Kammen, D. M. (2014). Spatial Distribution of US Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density. *Environmental Science & Technology*, *48*(2), 895-902.

[53] U.S. Energy Information Administration. (2015). Residential Energy Consumption Survey 2015.

[54] U.S. Census Bureau. (2019). TIGER/Line FTP Archive: 2019 ACS.

[55] U.S. Energy Information Administration. (2021). Residential Sector Energy Price and Expenditure Estimates, 1970-2019, Minnesota.

3. Findings

3.1 Populations Living Near Power Plants

Populations living close to power plants have some of the highest health impacts *per capita* from facility-related $PM_{2.5}$, which we will discuss in the $PM_{2.5}$ modeling sections below. In addition, many environmental health hazards and concerns are not reflected in this $PM_{2.5}$ modeling, such as the air pollution from diesel used in industrial equipment at the facility and from trucks coming to and from the site, the ground and water pollution from on-site disposal of waste, and non-$PM_{2.5}$ air pollutant emissions. While the health impacts of such pollution may be difficult to model directly due to a wide range of factors, including lack of sufficient data, they still pose potential equity concerns for populations nearby. To evaluate these concerns, we analyze the demographics of populations living near power plants and, to the extent possible, quantify some of the environmental health hazards posed by these plants. **Figure 1** shows the location of Hibbard, Boswell, and Laskin in relation to Minnesota Power's utility service territory and certain population indicators: communities of color, low-income communities, and rent-burdened communities. Notably, tribal lands stand out for their proximity to the power plants.

We built on this initial view by looking at *cumulative* socioeconomic burdens for census tracts across the state. As described in **Section 2.1** we combined indicators for low-income populations, populations of color, under age 5, over age 64, linguistic isolation, and low educational attainment to create a Demographic Index, mapped in **Figure 2**. This index mirrors some, but not all, of the indicators mapped individually in **Figure 1**, including tribal land boundaries. These combined metrics may indicate locations where populations are both particularly vulnerable to environmental pollution and where economic savings from measures such as energy efficiency may be particularly beneficial, as we discuss later in **Section 3.5**.

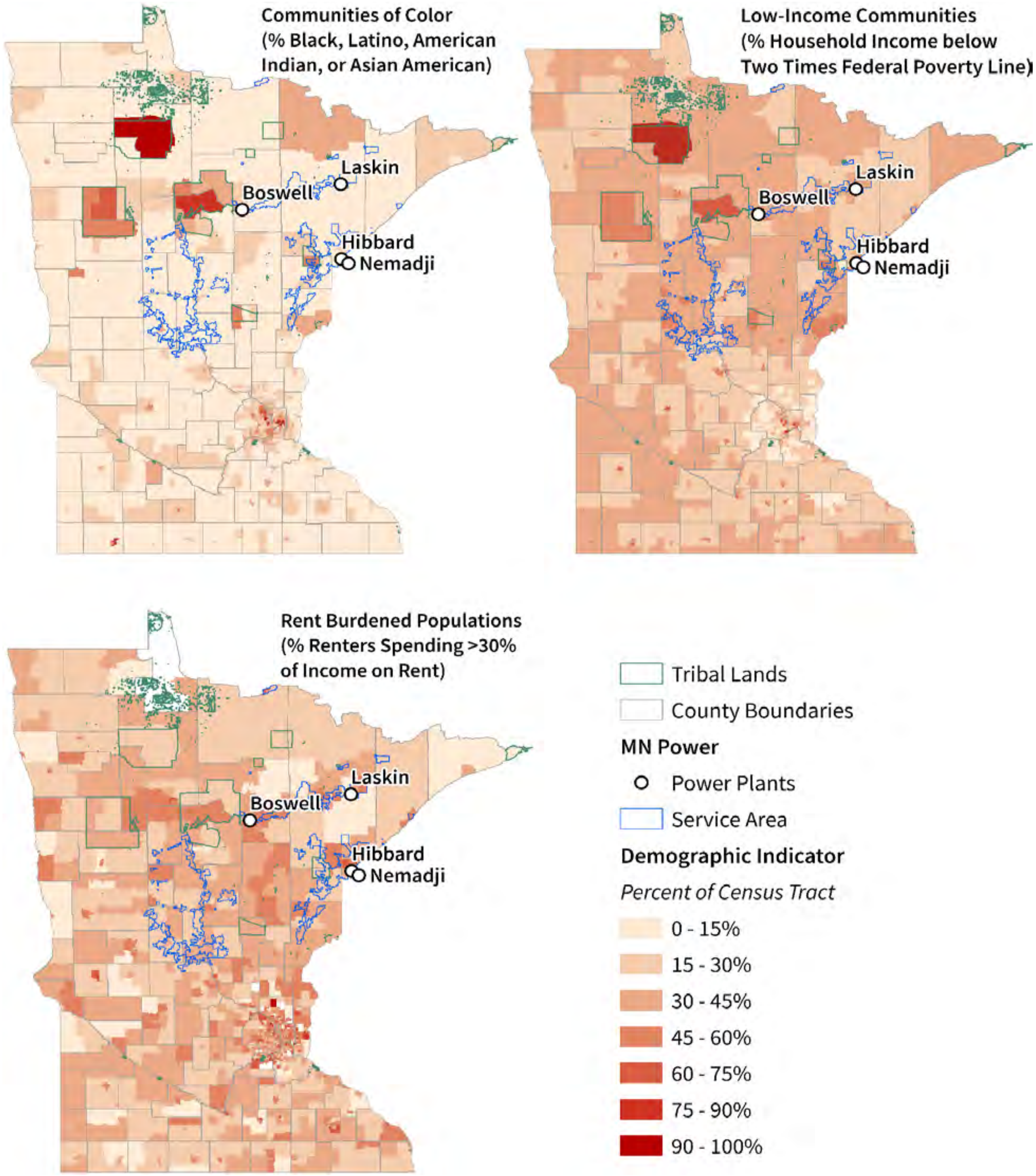

Figure 1. Map of select demographic indicators, power plants, and Minnesota Power territory. The map illustrates where low-income populations, communities of color, and rent-burdened populations are prevalent across Minnesota, near Minnesota Power's facilities, and in Minnesota Power territory.

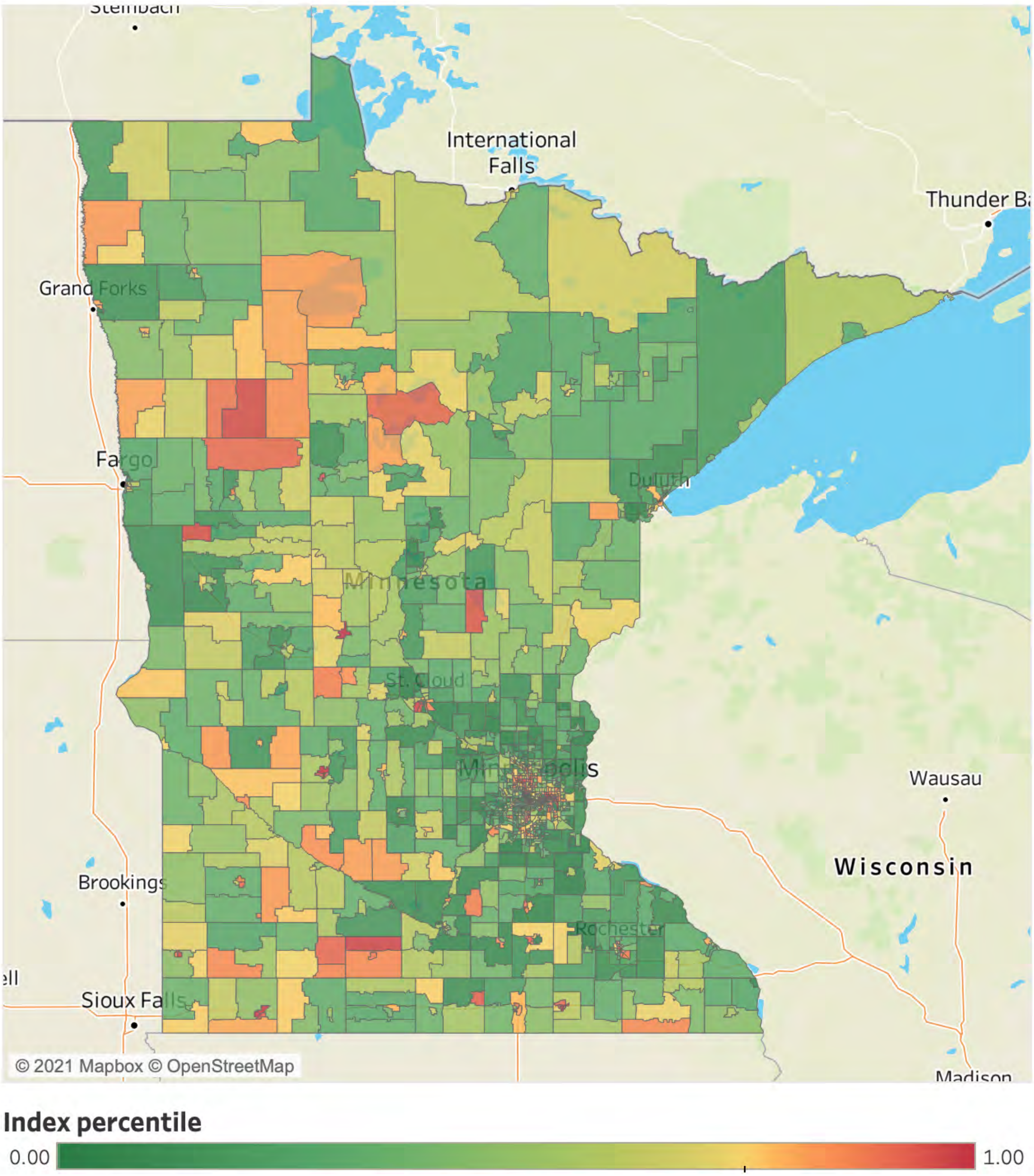

Figure 2. Demographic Index for Minnesota. Census tracts colored orange and red rank in the top quarter of census tracts for a combination of six socioeconomic indicators: low-income, population of color, under age 5, over age 64, linguistically isolated, and low educational attainment.

We next analyzed populations living within a one-mile and three-mile radius of each power plant using this Demographic Index. As our models will show in Section 3.2.4, the health impacts of these power plants extend far beyond a three-mile radius, but by analyzing the populations near to the plants we can get a sense of which populations may have the highest per-capita health impacts as well as those more likely to be exposed to additional air-, water-, and soil-based pollution pathways beyond $PM_{2.5}$. In **Figure 3**, we plot demographic indicators for the population living within one mile of each facility. We omit Milton R. Young due to very low population density near the plant. The x-axis represents the *state percentile* for population of color. For example, a state percentile of 55 would indicate that the population living near the plant has a higher concentration of people of color than 55 percent of census tracts statewide. On the y-axis we plot the state percentile for low-income populations. The bubble size reflects the total population living within one mile, so a larger bubble means more people live nearby. The bubble is colored by the Demographic Index value for the nearby population, reflecting the values calculated in **Figure 2**. We also include the proposed NTEC facility, although we note that the values used here are Wisconsin-specific, while Hibbard, Boswell, and Laskin are plotted using Minnesota-specific values.

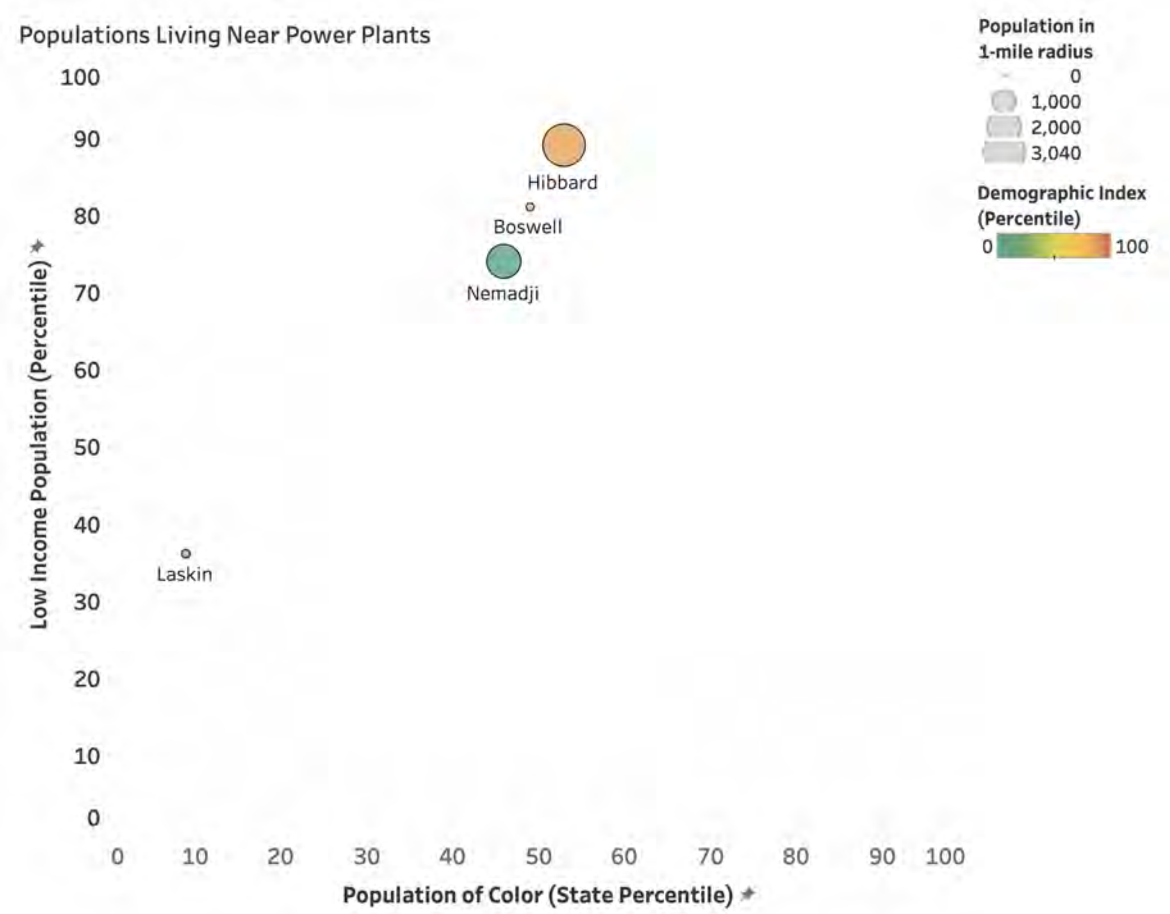

Figure 3. Demographics of populations living within one mile of existing and proposed power plants in MP's 2020 Plan. Circle radius indicates population size living within one mile of the plant. The x-axis indicates the state percentile for the population of color living within one mile of each plant, and the y-axis reflects the state percentile for low-income populations living within one mile. Bubble color reflects the Demographic Index for each population. Nemadji (NTEC) is compared to Wisconsin populations rather than Minnesota populations for state percentile calculations. Milton R. Young is omitted due to lack of sufficient population living within one mile of the plant.

The Hibbard Energy Center in Duluth, in particular, stands out as having a comparatively large population living nearby (more than 3,000 people in a one-mile radius and nearly 30,000 people within three miles. The proposed NTEC facility also borders an urban area, with nearly 2,000 people living within one mile and nearly 15,000 people living within three miles. The population within one mile of Hibbard ranks at the 89th percentile for low-income population and ranks at the 78th percentile on our Demographic Index; the population within one mile of Boswell ranks at the 81st percentile for low-income populations and ranks at the 71st percentile on the Demographic Index; and NTEC ranks in the 74th percentile for low-income population in Wisconsin and 66th percentile on our demographic index. All these plants rank near the state median for population of color. Laskin ranks relatively low on most indicators. These values suggest that Hibbard, Boswell, and the proposed NTEC facility are all located near populations with relatively high cumulative socioeconomic burdens, and that these populations may be particularly vulnerable to the health hazards posed by these plants.

3.2 Coal Power Plants

3.2.1 Baseline 2018-2020 Coal Plant Air Pollutant Emissions

Minnesota Power plans to continue to receive power from two existing coal plants over some or all of the period 2020-2035: Boswell Energy Center (Units 3 and 4) and Milton R. Young, located in North Dakota. We report the average annual *total* emissions and *rate* of emissions per unit MWh generated by Boswell Energy Center Units 3 and 4[56] and by Milton R. Young in **Table 1** and **Table 2.** We report values for Boswell units 3 and 4 separately because MP's 2021 Plan includes different retirement dates for each unit. Values are averaged for 2018-2020 unless otherwise indicated in the Methodology section.

Table 1. Average annual coal power plant emissions (2018-2020).

Plant Name	Primary Fuel	Generation *MWh*	Carbon Dioxide (CO_2) *Metric Tons*	Nitrogen Oxides (NO_x) *Metric Tons*	Sulfur Dioxide (SO_2) *Metric Tons*	Particulate Matter ($PM_{2.5}$) *Metric Tons*	Volatile Organic Compounds (VOCs) *Metric Tons*
Boswell 3	Coal	1,975,000	1,906,000	515.1	120.0	58.6	2.6
Boswell 4	Coal	3,652,000	3,556,000	1785.3	433.9	170.4	4.8
Milton R. Young[57]	Coal	5,258,000	5,210,000	7995.8	2453.3	40.9	7.7

Table 2. Average annual coal power plant emissions rates (2018-2020).

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[56] We omit Boswell units 1 and 2, which ceased operation in 2018.

[57] These are the total emissions from Milton R. Young, but Minnesota Power only contracts for part of this plant's generation, which we discuss below.

Plant Name	**Generation** MWh	**Carbon Dioxide (CO_2)** Metric tons/MWh	**Nitrogen Oxides (NO_x)** Lbs/MWh	**Sulfur Dioxide (SO_2)** Lbs/MWh	**Particulate Matter ($PM_{2.5}$)** Lbs/MWh	**Volatile Organic Compounds (VOCs)** Lbs/MWh
Boswell 3	1,975,000	0.97	0.57	0.13	0.07	0.0029
Boswell 4	3,652,000	0.97	1.08	0.26	0.10	0.0028
Milton R. Young	5,258,000	0.99	3.35	1.03	0.02	0.0032

The *total* emissions reported provide an initial indication of which power plants have the greatest total pollutant impacts. The emission *rates* given an indication of where displacing a MWh of generation with a MWh of clean generation would reduce the most emissions. For example, Milton R. Young has the highest total emissions of CO_2, NO_x and SO_2 as well as the highest emission rates of these pollutants per MWh. Boswell Unit 4 has higher emission rates for most pollutants than Unit 3. In **Figure 4**, we show the emissions per MWh for each of these facilities. This comparison provides an apples-to-apples comparison of potential benefits of alternatives, as each facility currently generates different quantities of electricity.

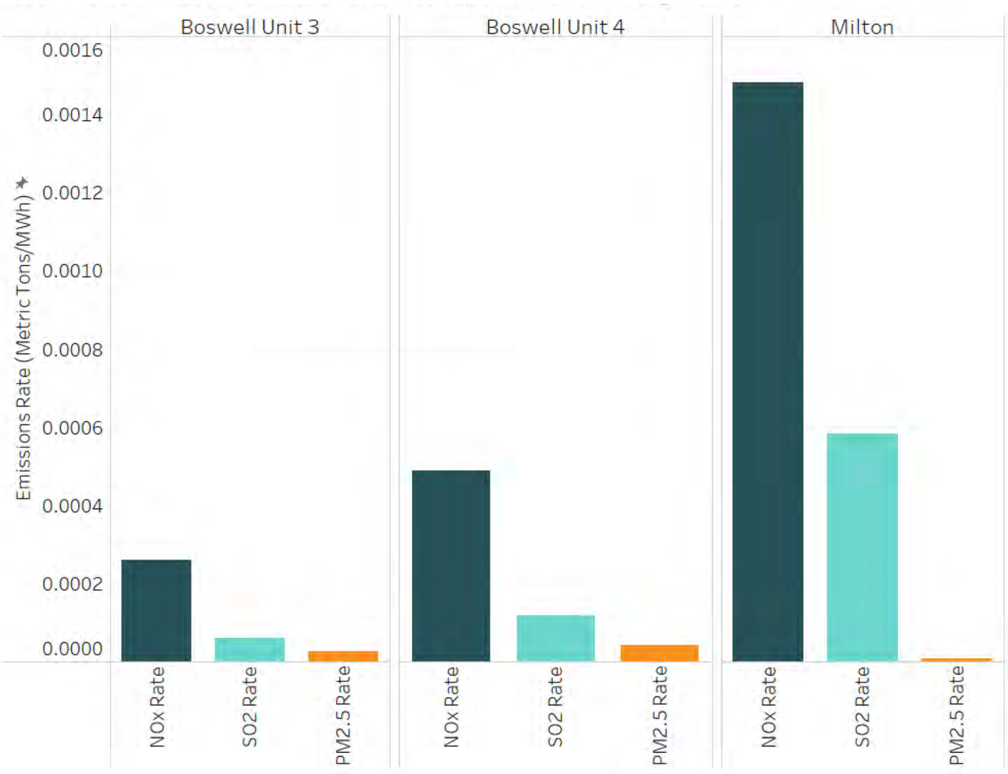

Figure 4. Criteria pollutant emission rates per MWh of electricity generation. Based on 2018-2020 emissions and generation.

3.2.2 Baseline 2021 Coal Plant Health Impacts

We calculated the baseline health impacts for each of the currently operating coal units for the 2021 model year using the Mid-Carbon Regulation Scenario in MP's 2021 Plan. We modeled these impacts by applying the emission factors in **Table 2** to the Plan's estimated 2021 generation and inputting these values into COBRA. The 2021 estimated total health impacts, by health outcome, are reported in **Table 3.** The modeled 2021 emissions estimates may not match the actual 2021 values, due to differences in modeled vs. actual energy generation. However, the emissions and generation are not yet fully reported at the time of writing; furthermore, 2021 electricity demand was likely impacted by COVID-19, and the modeled generation may better reflect typical annual operations.

Table 3. Estimated 2021 coal power plant health impacts. Health impacts are estimated based on historic emission factors and estimated 2021 generation in MP's 2021 Plan.[58]

Plant Name	**Mortality** (high est.)	**Upper Respiratory Symptoms**	**Respiratory Hospital Admits**	**Nonfatal Heart Attacks** (high est.)	**Infant Mortality**	**Total Health Impacts ($)**
Boswell Unit 3	1.6	14.7	0.16	0.67	0.003	$17,196,087
Boswell Unit 4	4.6	43.2	0.47	2.0	0.01	$50,493,432
Milton R. Young	3.5	36.5	0.4	1.6	0.01	$38,933,940

Table 3 indicates that Boswell (Units 3 and 4 combined)—which is located closer to population centers than Milton R. Young—has the greatest total health impacts, including an annual estimated mortality impact of 6.2. This calculation is in line with estimates from Clean Air Task Force's *Toll from Coal* analysis, calculated to be 8 mortalities per year.[59]

3.2.3 Scenario-Based Coal Plant Health Impacts 2021-2035

Minnesota Power proposes to continue to operate these three coal units to meet capacity needs for some or all of the 2021-2035 period. The Plan assumes that Boswell 3 will shut down by the end of 2029 and Boswell 4 will cease burning coal by the end of 2035. Milton R. Young is phased out of Minnesota Power's portfolio by the end of 2025. We analyzed the annual and cumulative 2020-2035 health impacts associated with MP's 2021 Plan using COBRA. The total health impacts over the 2021-2035 period are given in **Table 4.** If Boswell Unit 3 were to retire at the end of 2024 rather than 2029, it would save approximately 3-4 lives and reduce health

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[58] Milton R. Young impacts only reflect the portion of power contracted for by Minnesota Power, which we calculated by assigning emissions to Minnesota Power proportional to the electricity contracted as a fraction of total generation.

[59] Clean Air Task Force (2021). Toll from Coal. https://www.tollfromcoal.org

impacts by $39,100,000. If Boswell Unit 4 were to retire at the end of 2029 rather than running through 2035, it would save 14-15 lives and reduce health impacts by another $164,152,000.

Table 4. 2021-2035 cumulative coal power plant health impacts, modeled by COBRA.

Plant Name	**Mortality** (high est.)	**Upper Respiratory Symptoms**	**Respiratory Hospital Admits**	**Nonfatal Heart Attacks** (high est.)	**Total Health Impacts ($)**
Boswell Unit 3	9.3	88.6	0.97	4.1	$104,249,043
Boswell Unit 4	38.2	364.4	4.0	16.8	$429,737,900
Milton R. Young	9.9	102.3	1.1	4.5	$109,740,750

We show projected cumulative 2021-2035 emissions in **Figure 5**. This figure only includes the emissions from Milton R. Young for power contracted by Minnesota Power; some of Milton R. Young's generation is delivered elsewhere and this power is not subject to this IRP process.

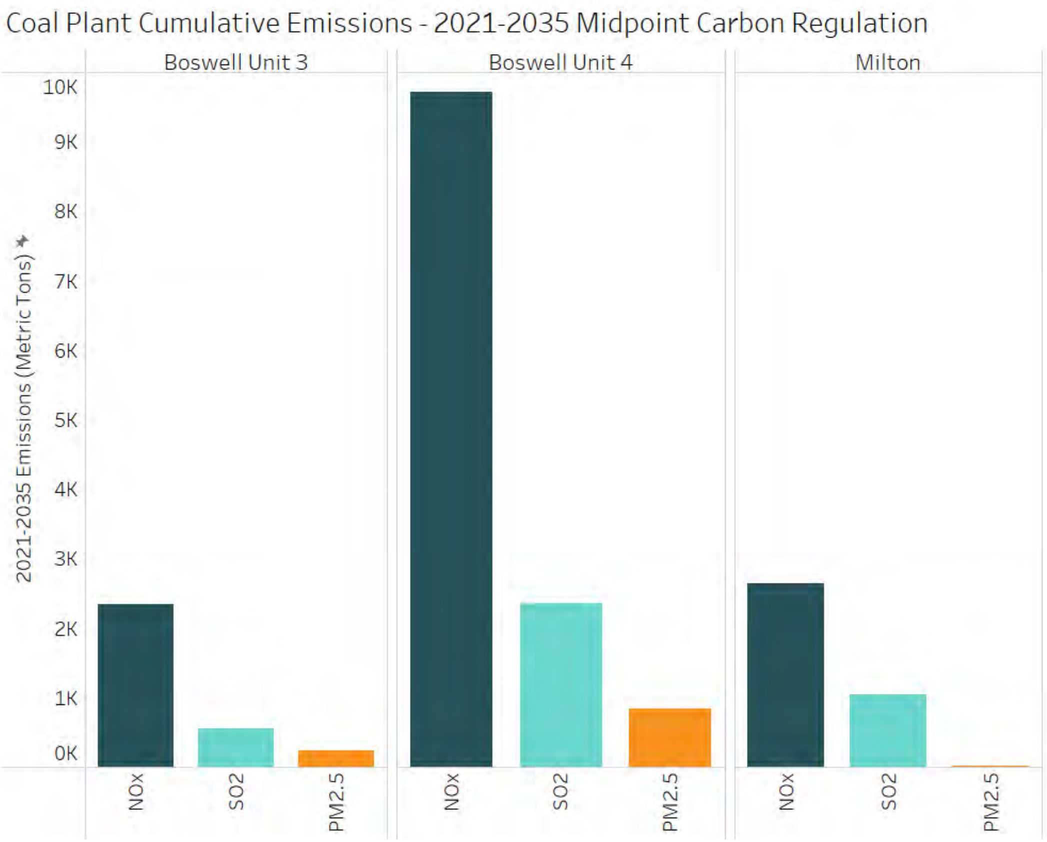

Figure 5. Modeled total 2021-2035 coal power plant emissions. Data reflect the 2021-2035 Mid-Carbon Regulation Scenario from MP's 2021 Plan. Emissions for Milton R. Young only reflect power contracted by Minnesota Power.

In **Figure 6** we show the cumulative health impacts from each coal plant over 2021-2035 based on projected use in MP's 2021 Plan. **Figure 6** illustrates the particularly high health impacts from Boswell 4 as compared to other facilities in Minnesota Power's portfolio.

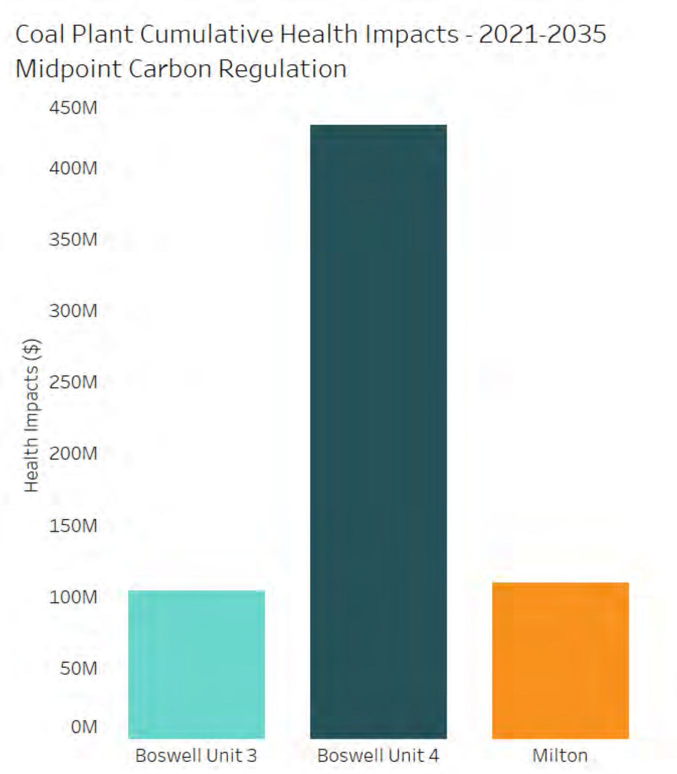

Figure 6. Modeled total 2021-2035 coal power plant health impacts ($). Data reflect the 2021-2035 Mid-Carbon Regulation Scenario from MP's 2021 Plan. Emissions for Milton R. Young only reflect power contracted by Minnesota Power.

3.2.4 Spatial Distribution of Coal Power Plant Health Impacts

We next used InMAP to model the spatial distribution of $PM_{2.5}$-mortality for each of the coal plants. We used the same Mid-Carbon Regulation Scenario 2021 emissions data for InMAP as we did for the COBRA model. The total health impacts from each plant (reported in $) are mapped in **Figure 7.** These impacts are highest near to and downwind from each facility, but clearly extend across state borders. Notably, Milton R. Young is located in North Dakota, but its cumulative health impacts in Minnesota are actually slightly higher than in North Dakota itself. Boswell Energy Center has significant impacts in Minnesota, but also in states downwind. It is worth noting that the health impacts in Canada are not reflected in this analysis, so these maps do not reflect the full $PM_{2.5}$-related human health impacts of these plants.

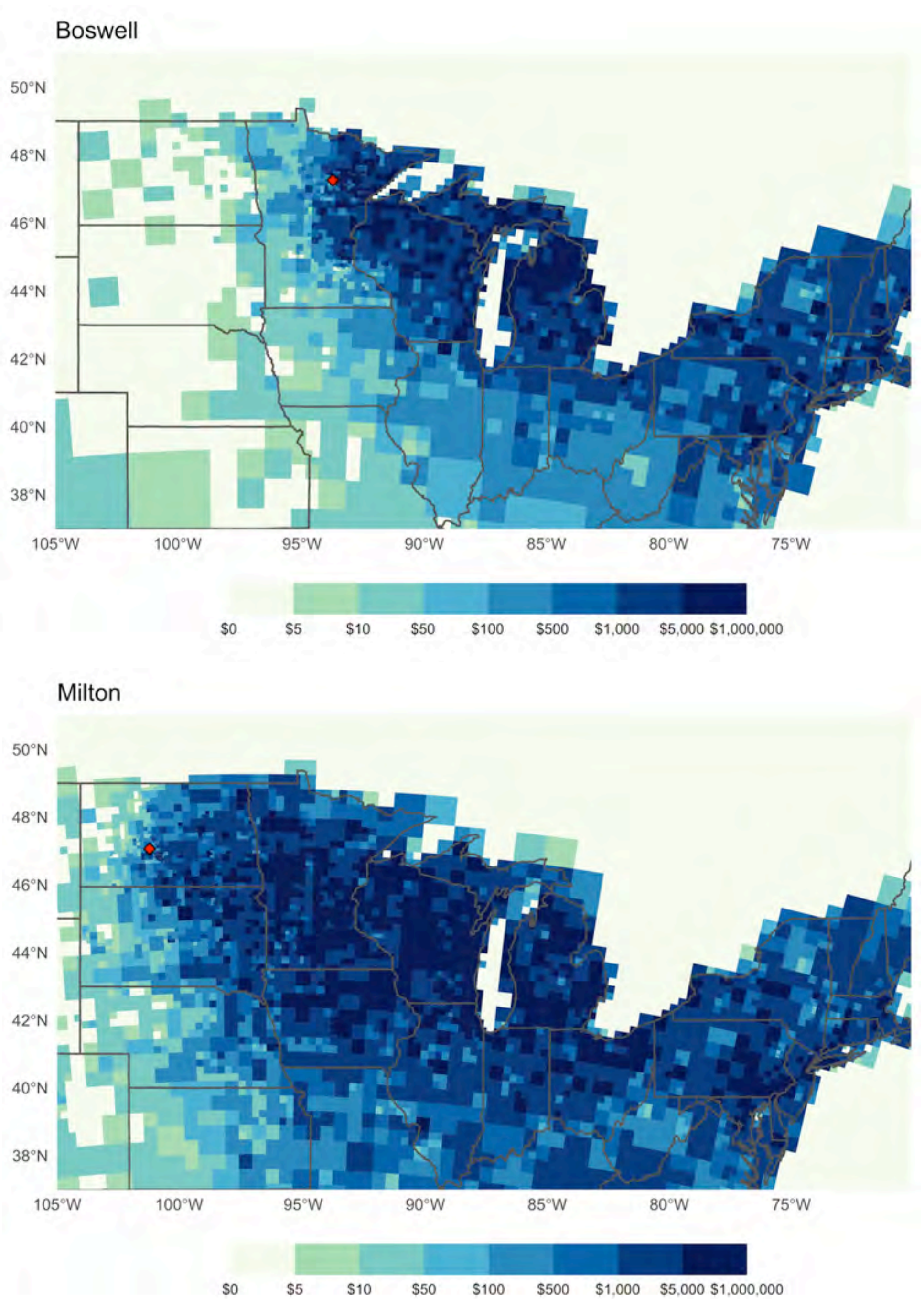

Figure 7. Cumulative $PM_{2.5}$ public health impacts of each of the coal plants (2021 model). Values are given in $. The location of each plant is shown as a red dot. Health impacts were only evaluated in the contiguous U.S. Grid cells outside of the U.S. are shown as zero. Maps are from InMAP model runs using 2021 Mid-Carbon Regulation Scenario emissions and include only mortality as a health outcome and do not include a discount rate in the economic valuation.

Table 5. Per capita coal plant health impacts by race and ethnicity. Data are from InMAP model runs. The analysis included only mortality as a health outcome and did not include a discount rate in the economic valuation.

Plant Name	**Black** *$/100 people*	**Latino** *$/100 people*	**Native** *$/100 people*	**Asian** *$/100 people*	**White** *$/100 people*	**Overall** *$/100 people*
Boswell	0.8	0.6	9.9	1.0	4.8	3.4
Milton R. Young	1.8	1.3	10.7	2.1	5.6	4.2

In order to determine where human populations are *disproportionately* impacted by the emissions from each plant, we also mapped the *per-capita* $PM_{2.5}$-mortality estimates from each plant (reported in $ per person) in **Figure 8.** These per-capita impacts are important for equity considerations related to these power plants. For example, the highest cumulative health impacts of the power plants are often located in the downwind city closest to each plant, but this only captures half the story; a plant located in a rural area, for example, might have low cumulative impact on nearby populations because not many people live there, but the per-capita impact may still be very high, indicating a disparity in impacts. As noted previously, these analyses only include the $PM_{2.5}$-related health impacts of these plants and are therefore likely an underestimate of the total health impacts. For example, plant emissions also contribute to the formation of ozone, which also contributes to respiratory and cardiovascular health impacts near and downwind from these facilities.

In **Table 5** we show these per-capita health impacts broken down by race and ethnicity. For every plant analyzed, the health impacts per capita were highest for Native populations, and larger by a factor of two to three as compared to the population at large. This result is likely due to the location of many of these plants upwind or near to Tribal Lands. For example, Boswell Energy Center is located just outside the Leech Lake Reservation, and upwind from the Fond du Lac and Milles Lac Reservations. The per-capita health impacts are also higher for White populations than the population at large, although not as much as for Native populations. These results are likely due to the higher share of White and Native populations living in rural areas where most of these facilities are located. In addition to the human health impacts, both Tribal and non-Tribal populations have expressed concern (in personal communication with our team) about how pollution from these plants affects animals and the environment, including mercury poisoning of fish.

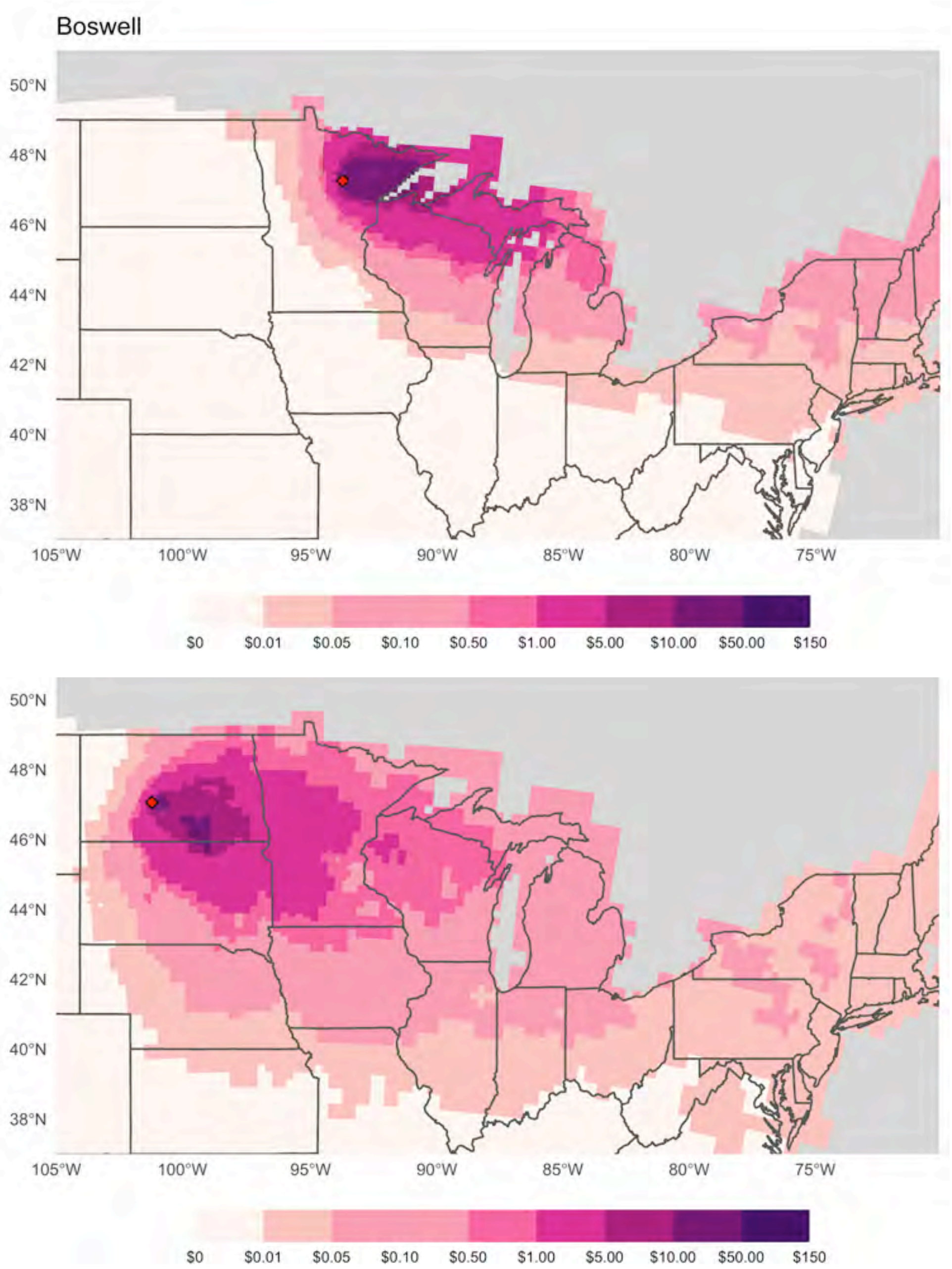

Figure 8. Per capita $PM_{2.5}$ public health impacts of each of the two coal plants (2021 model). Values are given in $ per person. The location of each plant is shown as a red dot. Health impacts were only evaluated in the contiguous U.S. Grid cells. Cells outside of the U.S. are shaded in gray. Maps are from InMAP model runs using Mid-Carbon Regulation Scenario emissions data for 2021. The analysis only included mortality as a health outcome and did not include a discount rate in the economic valuation.

3.2.5 Coal Plant Ash Disposal

In order to assess additional environmental health hazards associated with Minnesota Power plants, we aggregated waste disposal from and groundwater pollutant measurements near the two coal plants serving Minnesota Power: Milton R. Young and Boswell Energy Center.

Coal ash waste produced at Boswell is disposed of in coal ash ponds. The aerial view of the coal ash impoundment by Boswell Energy Center is shown in **Figure 9**. Boswell released 804 metric tons of waste on-site in 2020.[60] Of the pollutants recorded in the EPA's Toxic Release Inventory, the highest-mass source of waste was barium, followed by manganese, copper, vanadium, chromium, zinc, hydrochloric acid, sulfuric acid, and lead. The EPA's Highest Risk-Screening Environmental Indicators score for these pollutants, reflecting quantity of waste and human hazard, was highest for chromium (which is associated with cancer, gastrointestinal, blood, and respiratory impacts) and lead (associated with cancer, childhood neurological development, cardiovascular, and other impacts). A 2021 inspection rated the Unit 3, Unit 4, and Bottom Ash Surface Impoundment at Boswell as a *significant hazard* to the environment and nearby infrastructure in case of failure.[61]

Ashtracker aggregated pollutant measurements from groundwater monitoring wells at Boswell during 2016 and 2017.[62] Of Boswell's 17 monitoring wells, 10 recorded exceedances of federal pollutant standards during this period, including for arsenic, boron, cobalt, lithium, molybdenum, and sulfate. These exceedances pose risks to nearby populations, downstream populations, and particularly any households nearby that use wells to provide drinking water.

Boswell has had five inspections over the past five years according to the EPA's Toxic Release Inventory.[63] During that time, it spent four quarters (a total of 12 months) in noncompliance with the Clean Water Act, including one for significant violations.

Figure 9. Boswell Energy Center's coal ash ponds.[64]

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[60] U.S. Environmental Protection Agency.(2021). Toxic Release Inventory (TRI) Program.
[61] CCR Surface Impoundments Periodic Hazard Potential Classification, and Structural Stability and Safety Factor Assessment
[62] Environmental Integrity Project. (2019). Boswell Energy Center. *Ashtracker.*
[63] U.S. Environmental Protection Agency. (2021). Toxic Release Inventory (TRI) Program.
[64] Image source: Google. (2021). Maps.

Assuming that Boswell continues to produce waste at current rates for every MWh of electricity generated, we project that MP's 2021 Plan would lead to on-site disposal of an additional 6,240 metric tons of waste from 2021-2035. Retiring Boswell Unit 3 by 2025 would reduce approximately 690 tons of waste, and retiring Boswell Unit 4 by 2030 would reduce another 1,570 metric tons of on-site waste disposal, reducing pollution hazards to nearby communities.

In **Figure 10** we show an aerial view of the coal ash impoundment at Milton R. Young in North Dakota. According to the EPA's Toxic Release Inventory, Milton R. Young released 2,130 metric tons of waste on-site and 608 tons off-site in 2020.[65] By mass, pollutants recorded included barium, manganese, arsenic, vanadium, chromium, zinc, copper, and hydrochloric acid. The pollutants with the highest EPA Risk-Screening Environmental Indicators score were arsenic (associated with cancer, neurological, developmental, respiratory, skin, and other health impacts) and chromium. Milton R. Young produced more than twice the solid waste per MWh of generation than Boswell. While Milton R. Young's Alternate Bottom Ash Pond was rated as a *low* hazard in a 2011 inspection report, its Cell 1 and Cell 2 disposal sites are considered *significant* hazards.[66] The Alternate Bottom Ash Pond was rated as *fair* and Cell 1 and Cell 2 as *satisfactory.*

Ashtracker reports that one of six groundwater monitoring wells at Milton R. Young recorded exceedances of federal standards for arsenic and radium when measured in 2016 and 2017. According to the Toxic Release Inventory, Milton R. Young has had 12 inspections over five years, during which it spent five quarters in noncompliance with the Clean Water Act, two quarters of which it was in significant violation.

Figure 10. Coal ash impoundment at Milton R. Young.[67]

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[65] U.S. Environmental Protection Agency. (2021). Toxic Release Inventory (TRI) Program.

[66] GEI Consultants, Inc. (2011). Specific Site Assessment for Coal Combustion Waste Impoundments at Minnkota Power Cooperative Milton R. Young Station. *Prepared for the U.S. Environmental Protection Agency.*

[67] Image source: Google. (2021). Maps.

The ash associated with Minnesota Power's electricity procurement from Milton R. Young during 2021-2035 in the Mid-Carbon Regulation Scenario comes to a total of 720 metric tons on site and 230 off site.

3.2.6 Coal Plant Water Use

Boswell Energy Center withdrew 1.5 billion gallons of water for cooling in 2020 and consumed 1.0 billion gallons.[68] Based on projected generation, Boswell will consume 7.1 billion gallons from 2021-2035, but retiring Boswell 4 by 2030 would save 1.8 billion gallons of water.

Milton R. Young withdrew 173 billion gallons of water for cooling in 2019 and is projected to withdraw 69 billion gallons for cooling associated with Minnesota Power's contracted power (scaled proportionally) from 2021-2025.

3.3 Biomass Power: Hibbard

MP's 2021 Plan continues to utilize electricity from Hibbard, a biomass facility attached to a paper mill that has historically burned biomass waste (paper pulp) from the mill, along with some coal, and provided steam for the mill's operations. Over the planning period 2021-2035, Hibbard's projected generation declines (although from an estimated generation level in 2021 that is roughly three times higher than actually reported for 2020) and then increases again. However, the paper mill itself halted operations in 2020, while the plant has continued to produce electricity. Furthermore, the paper mill was sold in 2021 to a new operator[69] who has indicated the new facility will not use steam from the Hibbard plant.[70] It is unclear what fuel Hibbard is burning now that the paper mill is no longer operational. Historically, coal fueled up to 11 percent of the electricity generated annually at Hibbard (which occurred in 2019).[71] During 2020, fuel consumption dipped, possibly due to a combination of the pandemic and the idling of the paper mill, but fuel consumption has grown steadily since then and reached nearly historic levels as of October 2021. As noted previously, however, the total *electricity* generation has increased, and steam production has likely decreased. Given all these changes, the plant's future fuel source and level of electricity generation is uncertain.

Hibbard's 2018-2020 average electricity generation, steam production, and emissions are given in **Table 6.**

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[68] U.S. Energy Information Administration (2022). Electricity Data Browser.

[69] Mentzer, R. (2021). Sale of Duluth Mill Points to Paper Industry Trends. *Wisconsin Public Radio.*

[70] Minnesota Power response to Clean Energy Organizations Information Request No. 70

[71] U.S. Energy Information Administration (2021). Electricity Data Browser.

Table 6. Average annual emissions for Hibbard (2018 - 2020).

Plant Name	Primary Fuel	Generation *MWh*	Steam *Million Tons*	Carbon Dioxide (CO_2) *Metric Tons*	Nitrogen Oxides (NO_x) *Metric Tons*	Sulfur Dioxide (SO_2) *Metric Tons*	Particulate Matter ($PM_{2.5}$) *Metric Tons*	Volatile Organic Compounds (VOCs) *Metric Tons*
Hibbard	Biomass (paper pulp)	21,800	734	29,300	401	101	28	19

Hibbard's public health impacts going forward are hard to model given the described unknowns about steam production, electricity generation, and fuel source. Assuming that steam is going to continue to be produced in the same ratio to electricity as historically, the ongoing operation of Hibbard as modeled in MP's 2021 Plan from 2021-2035 would cause an estimated 38.9 mortalities, based on COBRA modeling, and a total of $437 in million in health impacts. The modeled health impacts for base year 2021 were 6.4 mortalities and $70 million in health impacts. However, these specific values should be interpreted with caution. The values we input into the model included air pollutant emissions per MWh of electricity generation reported historically, but do not directly reflect the fact that Hibbard has produced steam as well and these values have changed in the past year and are projected to continue to change. As mentioned above, Hibbard has recently reduced its steam production and increased its electricity generation in tandem with the idling of the attached paper mill, and the new owner of the paper mill will not use steam from the plant. This increase in MWh generated will likely cause air pollutant emissions *per MWh* to decline, though the scale of the impact is uncertain, and total emissions will remain high if the amount of electricity generated at the facility continues to increase. As such, the pollutant emissions from Hibbard should be monitored closely.

In **Figure 11**, we show the total and per-capita health impacts of Hibbard from InMAP. This InMAP modeling suggests that the facility poses significant health risks to nearby and downwind communities, and disproportionately so for Native populations (**Table 7**), but the actual impacts going forward are likely to change depending on how the plant is operated.

Table 7. Per capita biomass plant health impacts by race and ethnicity. Data are from InMAP model runs. The analysis included only mortality as a health outcome and did not include a discount rate in the economic valuation.

Plant Name	Black *$/100 people*	Latino *$/100 people*	Native *$/100 people*	Asian *$/100 people*	White *$/100 people*	Overall *$/100 people*
Hibbard	1.6	1.0	19.2	2.1	9.1	6.4

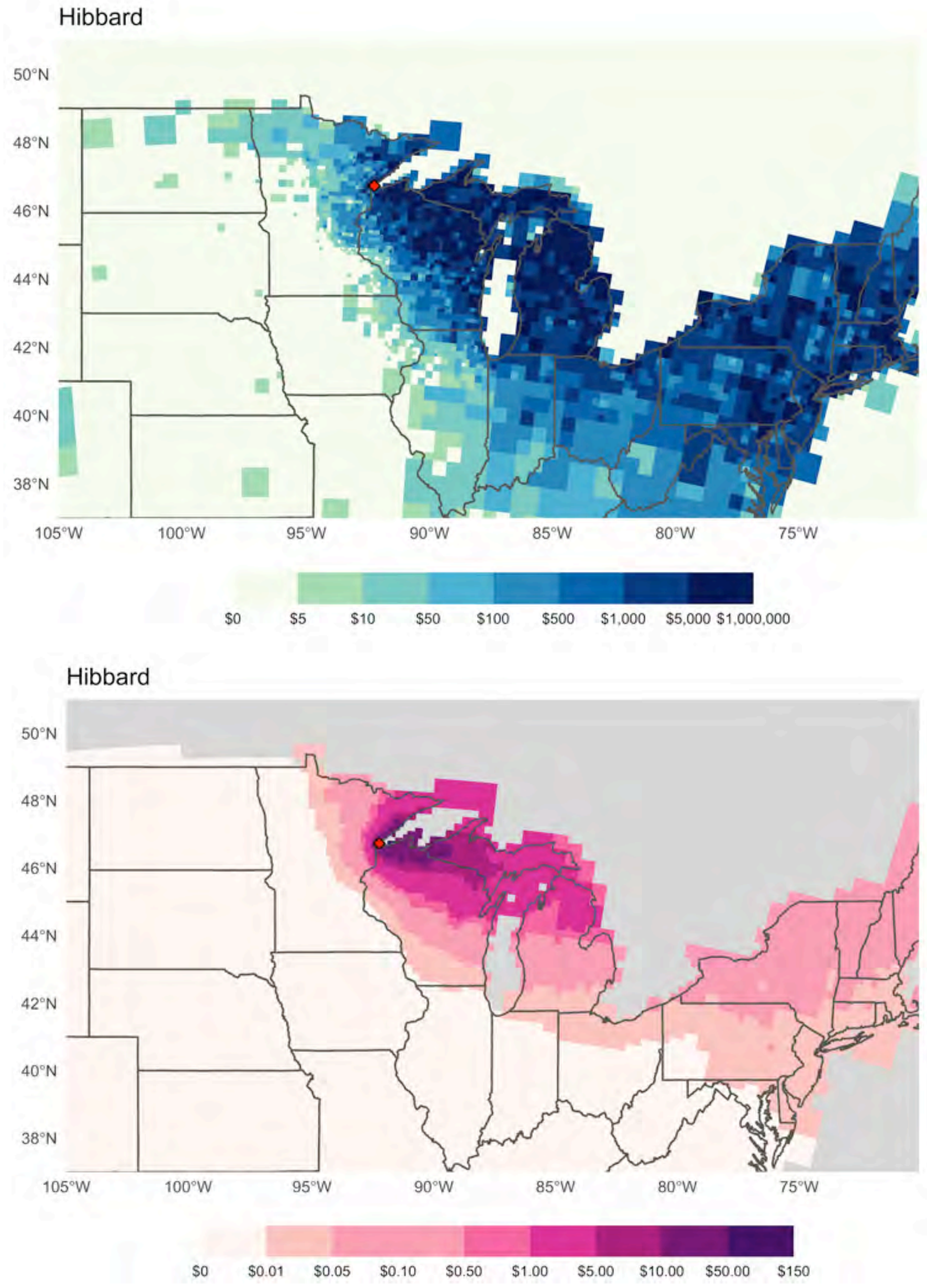

Figure 11. Total (top) and per-capita (bottom) health impacts from Hibbard for model year 2021. Values are given in $ and $ per person, respectively.

3.4 Gas Power Plants

MP's 2021 Plan relies on ongoing generation from Laskin, a former coal plant which now burns gas to meet limited periods of peak electricity demand, and the proposed NTEC natural gas combined cycle plant. Laskin is used infrequently—it generated an average of 16,300 MWh/year from 2018-2020—and has low pollutant emissions compared to other plants in Minnesota Power's portfolio, but its average NO_x emission rate during that period (1.8 metric tons/MWh) was actually higher than Boswell's. Since Laskin is used to meet peak energy demands, the emissions are likely to be released over a shorter period of time, which may lead to high short-term air quality and acute health impacts. For example, if Laskin is used to meet higher electricity demand on hot summer days, high NO_x emissions may contribute to increased ozone or secondary $PM_{2.5}$ formation, depending on background air pollutant levels and meteorological conditions. The modeled $PM_{2.5}$-related mortality impacts from Laskin from 2021-2035 sum to $5.4 million.

Both Laskin and NTEC are expected to rely on ongoing combustion of gas to generate electricity. Methane, a potent greenhouse gas and the primary constituent in gas fuel, is known to leak throughout the entire gas system, including during gas production, processing, transmission, and use.[72] A recent synthesis of the scientific literature addressing methane leakage found that in the US, methane leaks at a rate of approximately 2.3 percent of gas production, or 2.9 percent of gas delivered to end-users.[73] Fossil-sourced methane has a global warming potential (CO_2-equivalent, or CO_2e) of 30 over a 100-year time period and 83 over a 20-year time period.[74] The result of this methane leakage is that the global warming impacts of natural gas combustion are significantly higher than reflected in the direct CO_2 emissions reported at power plant stacks.

In this analysis, we use estimates from Alvarez et al. (2018)[75] to estimate the lifecycle greenhouse gas impacts of gas combustion at the proposed NTEC facility. This review indicates that the radiative forcing (global warming impact) of gas use is 92 percent higher than the direct CO_2 emissions from gas combustion alone over a 20-year time period, and 31 percent higher over 100 years. We use these factors to calculate the lifecycle greenhouse gas emissions associated with proposed gas use at NTEC. The Supplemental Environmental Assessment for NTEC suggests that the facility will produce 2.24 million tons of CO_2 per year, as well as 1,227 tons of methane and 1,564 tons of nitrous oxide, another potent greenhouse gas.[76] If we

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[72] Brandt, R.A., et al. (2014). Methane Leaks from North American Natural Gas Systems. *Science*, *343*(6172), 733-735.

[73] Alvarez, R.A., et al. (2018). Assessment of Methane Emissions from the US Oil and Gas Supply Chain. Supplementary Material. *Science*, *361*(6398), 186-188.

[74] Forster, P., et al. (2021). The Earth's Energy Budget, Climate Feedbacks, and 40 Climate Sensitivity. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I 41 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Table 7.15. *Cambridge University Press*. In Press.

[75] Alvarez, R.A., et al. (2018). Assessment of Methane Emissions from the US Oil and Gas Supply Chain. Supplementary Material. *Science*, *361*(6398), 186-188.

[76] Prevention of Significant Deterioration Air Construction Permit Application, Nemadji Trail Energy Center (2021).

incorporate lifecycle methane emissions into the greenhouse gas impacts of this plant (assuming that the Assessment's methane estimates are a subset of the lifecycle emissions estimated in Alvarez et al.,) NTEC's annual emissions are equivalent to 3.4 million tons CO_2e over a 100-year time period and 4.8 million tons CO_2e over a 20-year time period. These figures represent the annual emissions from the full plant. MP's portion of annual NTEC greenhouse gas emissions, based on a 20 percent ownership stake, is equivalent to 680,000 tons CO_2e over a 100-year time period or 960,000 tons CO_2e over a 20-year time period.

In addition to methane leakage, the upstream production, processing, and transmission of natural gas is associated with the emission of a wide range of health-damaging air pollutants, such as the carcinogens benzene, toluene, ethylbenzene and xylene (known collectively as BTEX), as well as NO_x, VOCs, and other criteria air pollutants.[77] These upstream pollutants are attributable to both fugitive emissions of non-combusted gasses from liquid storage tanks, pneumatic controllers, and other major equipment as well as combustion-related emissions from flares, gas-fired compressor stations, diesel-powered equipment, and other fuels used to power production operations. These emissions constitute a health hazard for populations living nearby and downwind and living near wells has been associated with such health concerns as adverse birth outcomes[78] and asthma[79,80] and is considered a cancer risk.[81] As such, the avoidance of gas combustion at NTEC can also help mitigate the upstream health hazards and risks associated with gas production and processing.[82]

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[77] Michanowicz, D. et al. (2021). Methane and Health-Damaging Air Pollutants from the Oil and Gas Sector: Bridging 10 Years of Scientific Understanding. *PSE Healthy Energy*.

[78] Tran, K. V., et al. (2020). Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births. *Environmental Health Perspectives*, *128*(6), 067001.

[79] Willis, M. D., et al. (2018). Unconventional Natural Gas Development and Pediatric Asthma Hospitalizations in Pennsylvania. *Environmental Research*, *166*, 402-408.

[80] Rasmussen, S. G., et al. (2016). Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations. *JAMA Internal Medicine*, *176*(9), 1334-1343.

[81] McKenzie, L. M., et al. (2018). Ambient Nonmethane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks. *Environmental Science & Technology*, *52*(8), 4514-4525.

[82] While not detailed in this report, reduced coal combustion will similarly reduce upstream environmental health impacts of coal production, lifecycle impacts such as the health hazards and risks associated with coal train transport, and downstream impacts such as mercury pollution in streams and waterways. We suggest these factors may be valuable for research in future analyses.

3.5 Equitable Energy Access

MP's 2021 Plan holds both direct and indirect implications for energy affordability. Many households struggle to pay their utility bills, and decisions made within the IRP can hold long-term implications for those bills. While actual utility rates are typically decided in rate cases, the resource portfolio selected within IRPs can still directly affect ratepayers. For example, a more expensive overall portfolio holds the potential to have those costs passed on to ratepayers. A riskier portfolio—such as one relying heavily on fossil fuels, which are subject to price variability and may turn into stranded assets in a carbon-constrained future—may similarly pose a future risk to ratepayers. Those who currently struggle the most to pay their utility bills are likely to be the most impacted by supply costs being passed on to them. More directly, however, the choice to incorporate resources such as energy efficiency or rooftop solar may provide more direct economic savings to households than utility-scale resources. MP's 2021 Plan outlines not only its proposed overall residential energy efficiency savings but also its proposed low-income energy efficiency savings; we can thus evaluate whether these resources are equitably distributed to energy cost-burdened households and whether other resource portfolios may better alleviate these energy cost burdens for those who most need it. We therefore analyze energy cost burdens in Minnesota Power territory, analyze efficiency and distributed solar resources within MP's 2021 Plan, and discuss the implications for resource selection in reducing energy cost burdens.

3.5.1 Assessing Energy Cost Burdens

Energy cost burden—the percentage of household income used to pay energy bills—is typically considered high if over six percent, although different jurisdictions may use higher or lower thresholds. We show the median energy cost burden by census tract for Minnesota Power's territory in **Figure 12.** These energy cost burdens include electricity, gas, and propane; even though MP's 2021 Plan only addresses electricity, it is important to evaluate the full energy cost picture in order to accurately understand the true energy cost burden a household faces and to make more accurate comparisons between houses that heat with electricity and those that heat with propane or gas. The tracts colored orange or red have energy cost burdens above four percent and are notably high in rural areas and particularly in parts of Duluth. It is worth noting that these are *average* energy cost burdens by census tract, meaning that some individual households may face much higher energy cost burdens, even in census tracts colored blue on the map. Accordingly, these maps can provide a sense of overall trends regarding where cost burdens may be high, but do not show the full range of energy cost burdens faced by individual households.

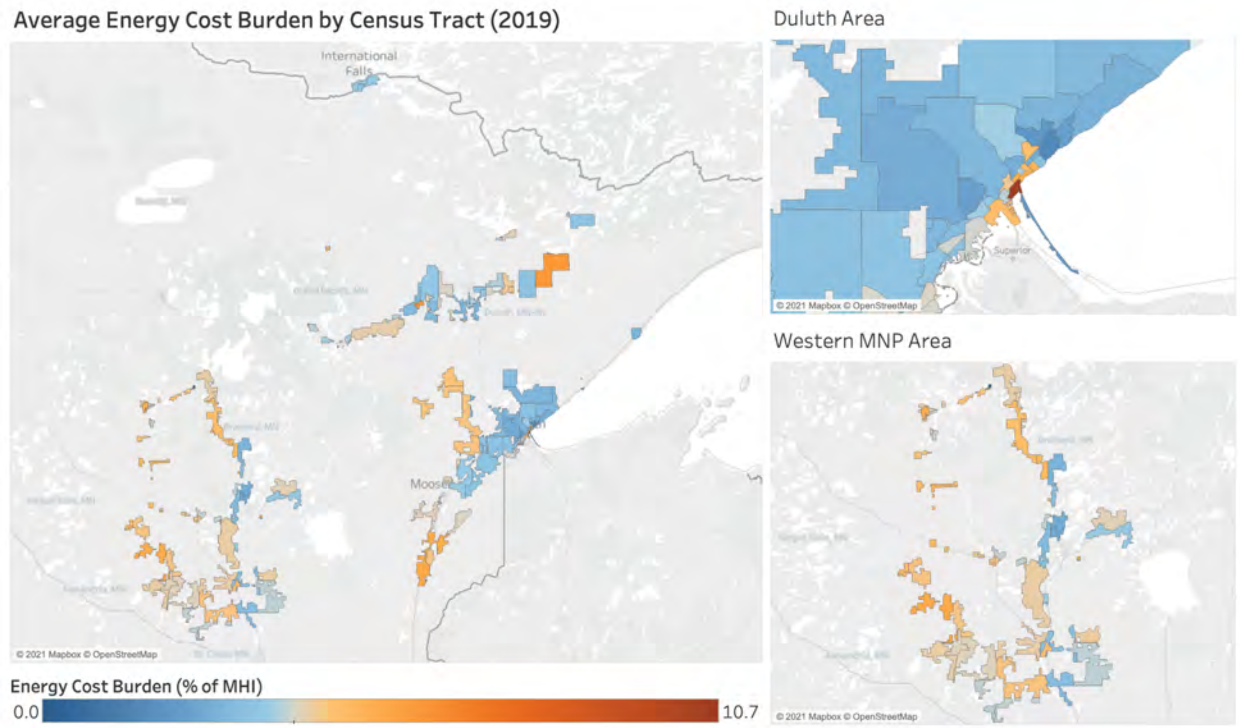

Figure 12. Average household energy cost burden by census tract. Census tracts with cost burdens over four percent are shown in orange and red. The highest census tract energy cost burdens are seen in Duluth and in rural areas. Note that individual households within each census tract may have much higher energy cost burdens than the tract average.

In **Figure 13,** we plot census tract energy cost burdens compared to median household income. By definition, energy cost burden is inversely related to household income. The relationship is non-linear, however, and lower-income census tracts tend to experience dramatically higher energy cost burdens compared to higher income census tracts. The highest estimated energy cost burden for an individual census tract in Minnesota Power's territory is 10.7 percent. This census tract is located in downtown Duluth and is also the census tract with the lowest median household income within Minnesota Power territory.

In **Figure 14**, we see that energy cost burdens are also high for census tracts with a high share of renters and for census tracts with a higher share of Black residents. These are all populations that may benefit from energy-saving measures, such as energy efficiency. Programs to increase access to such energy saving measures can help reduce the energy cost burden inequities of the existing system.

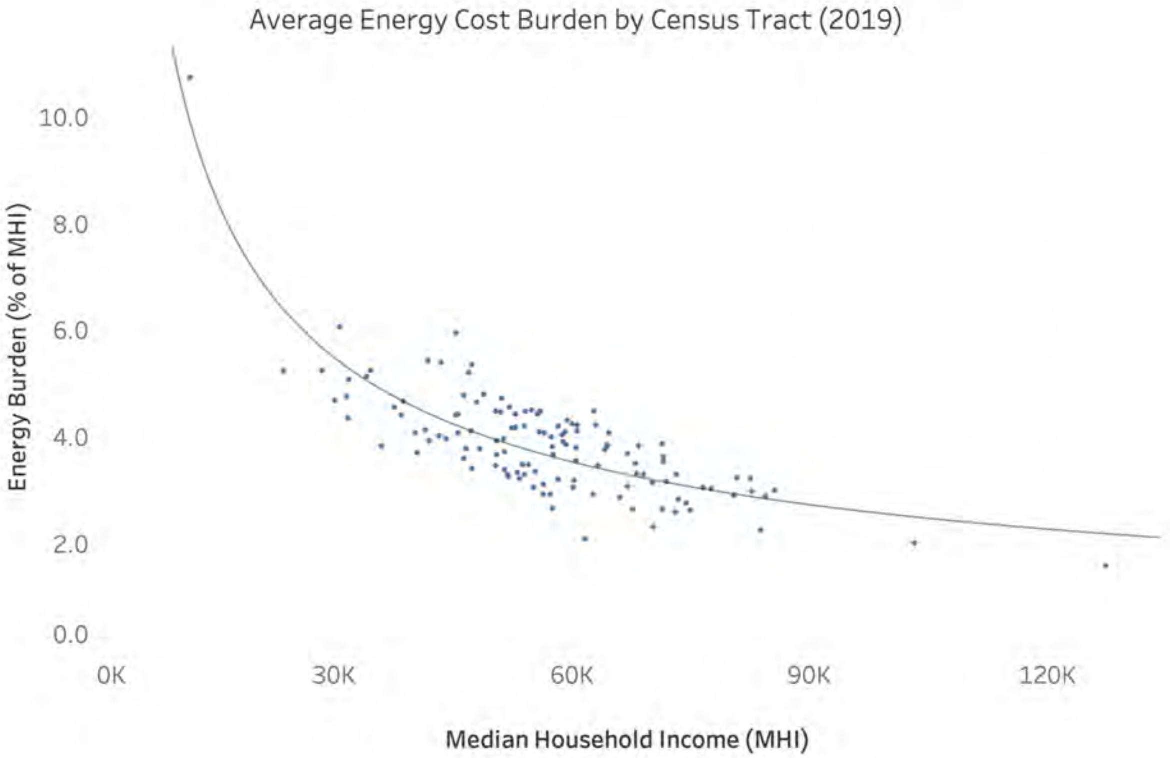

Figure 13. Energy cost burdens and median household income. Census tract average cost burdens are shown as a percent of median household income. Lower-income census tracts tend to spend a much greater fraction of their income on energy bills.

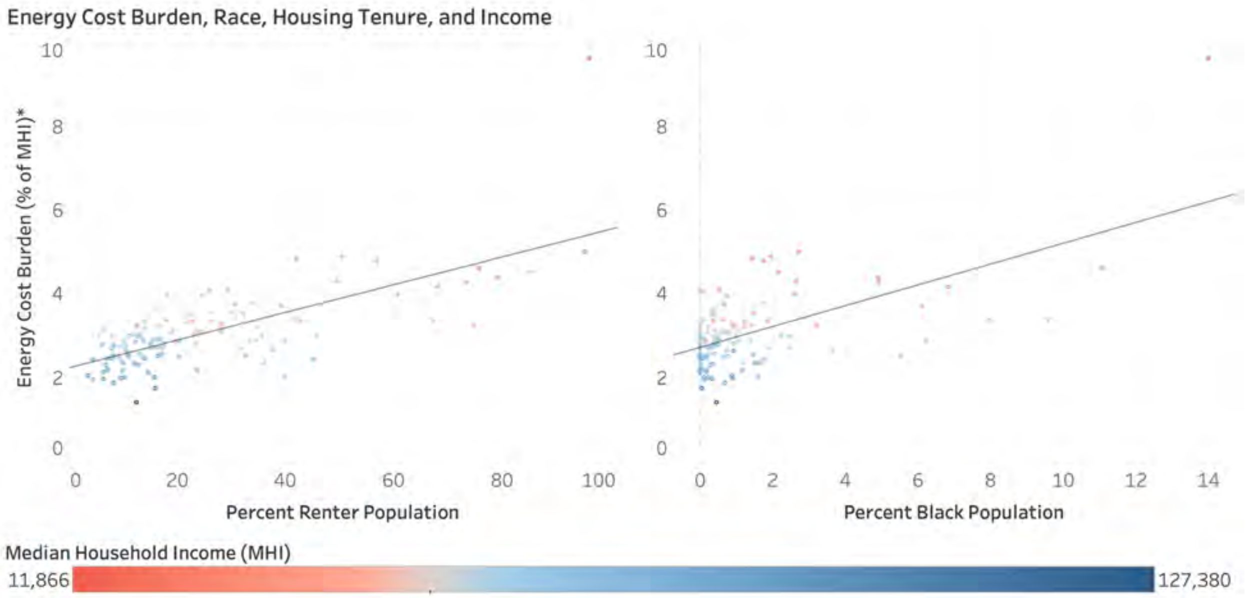

Figure 14. Energy cost burdens and population indicators. Electricity + natural gas cost burdens are higher for census tracts with a larger share of renters and for census tracts with a larger share of Black residents, both of which also tend to be lower income.

3.5.2 Efficiency and Solar Access in MP's 2021 Plan

We next analyzed the proposed residential energy efficiency and rooftop solar deployment in MP's 2021 Plan. The choice to invest more heavily in distributed energy resources, such as energy efficiency and rooftop solar, can significantly impact residential energy bills for the adopters. Weatherization and other energy-saving measures help reduce overall energy demand and provide long-term bill savings. Similarly, rooftop solar can provide long-term economic benefits and bill consistency through net metering policies. However, low-income households face numerous barriers to adopting clean energy technologies, including lack of access to capital, lower levels of home-ownership, linguistic isolation, and others. Efficiency programs that target low-income households directly need to be adequately funded in order to help reduce overall disparities in energy cost burden. At a minimum, funding for low-income weatherization and energy efficiency should be proportional to the fraction of low-income households within Minnesota Power territory. However, low-income programs are often more expensive to implement and the energy savings achieved per dollar invested are generally lower. A more equitable approach would therefore aim to guarantee proportional energy *savings* in low-income households rather than proportional funding.

We estimate that the low-income population in Minnesota Power territory (below 200 percent of the Federal Poverty Level) is about 30 percent. **Figure 15** shows the spatial distribution of low-income households by census tract based on the percentage of low-income population within each tract. We note the especially high concentration of low-income households in Downtown Duluth, Lincoln Park, Central Hillside, and East Hillside.

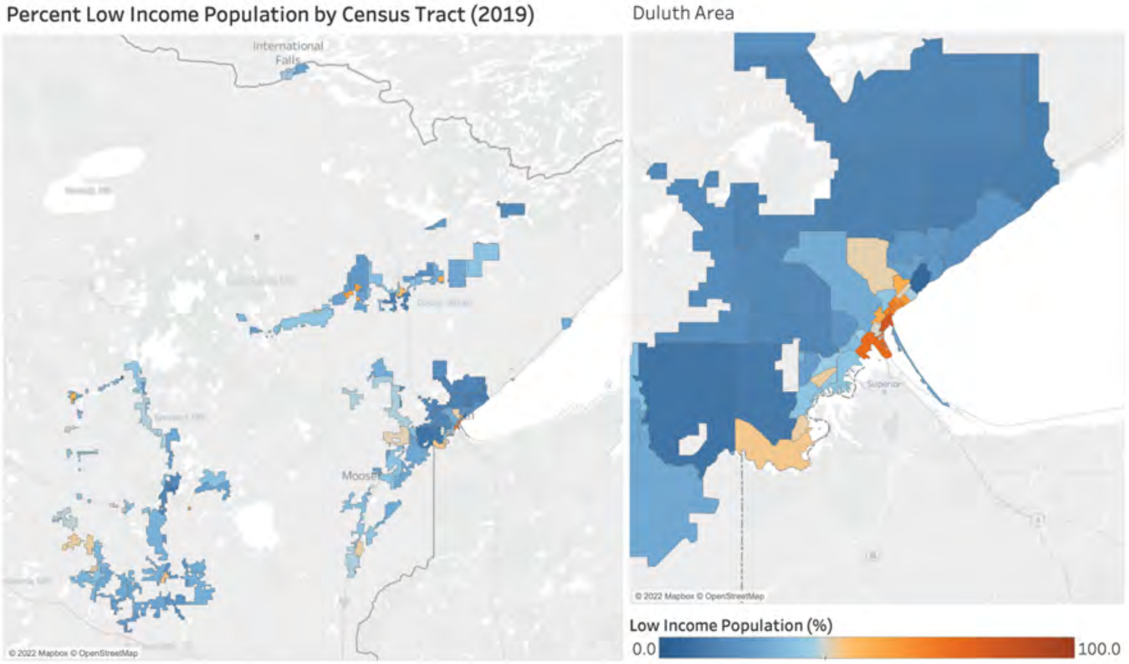

Figure 15. Distribution of Low-Income Population. Percentage of population with incomes below 200 percent of the Federal Poverty Level. The color break between blue and orange is set at 40 percent. Lower income communities are shown in orange.

Historically, Minnesota Power's energy efficiency investments in low-income communities have averaged 20 percent of total residential energy efficiency investments over the last four years (2017-2020). This number is substantially lower than the proportion of the low-income population in Minnesota Power territory, which, as mentioned above, is around 30 percent. What is more, the projected fraction of residential energy efficiency *savings* in low-income households over the next three years (2021-2023) is lower yet—the projected low-income energy savings are around 13 percent of the total projected residential energy savings as filed in the MP 2021-2023 CIP Triennial Filing.[83] In the longer timeframe (2024-2029), the projected energy savings in low-income communities are about 11 percent of total projected residential energy savings. Based on these numbers, we estimate that Minnesota Power investments in low-income residential energy efficiency need to be tripled as a fraction of the total levels of investment currently proposed in MP's 2021 Plan to not exacerbate further existing energy cost burden disparities. Alleviating the existing energy cost burden inequities would require additional funding for energy efficiency and weatherization in low-income communities. Minnesota's Energy Conservation and Optimization Act of 2021[84] requires an increase in spending on low-income energy efficiency programs. This bill may help facilitate an increase in low-income efficiency savings, although it is unclear to what extent the bill's increased requirements are already included in Minnesota Power's current projections. To ensure CIP programming reduces energy burden disparities, additional measures are likely needed.

In addition to the Baseline CIP Scenario, Minnesota Power has evaluated two alternative energy savings scenarios that begin in the year 2024 and go above and beyond the proposed Baseline scenario in terms of energy savings: 1) a "High" Scenario, and 2) a "Very High" scenario, modeled after the "Max Achievable" scenario of the 2020-2029 Minnesota State Demand Side Management Potential Study.[85] The High Scenario increases the total energy savings by about 25 percent and the Very High Scenario by over 50 percent compared to the Baseline efficiency scenario. However, both alternative scenarios project that only 11 percent of the overall energy savings would go to low-income households. As discussed above, this proportion is inequitable, given that the fraction of low-income population in Minnesota Power territory is closer to 30 percent. To achieve a meaningful reduction in energy cost burdens within its territory, Minnesota Power will need to ensure that at least one-third of the projected energy savings are attained in low-income communities. We recommend that Minnesota Power adopt the Very High efficiency scenario with the provision that one third of the projected energy savings go to low-income households. We estimate that this will more than quadruple the number of low-income households adopting energy-saving and bill-reducing measures annually. These efforts can be coupled with additional measures addressed in other dockets to comprehensively address energy cost burdens, such as the recently approved discounted time-of-day rates for low-income customers.[86]

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[83] Minnesota Power. 2021-2023 CIP Triennial Filing Docket No. E015/CIP-20-476

[84] Minnesota Legislature. (2021). HF 164: Energy Conservation and Optimization Act of 2021.

[85] Nelson, C. et al. (2018). Minnesota Energy Efficiency Potential Study: 2020–2029. *Prepared for the Minnesota Department of Commerce, Division of Energy Resources.*

[86] Citizens Utility Board. (2021). Minnesota Power to Transition to Time-of-Day Rates.

3.5.3 Existing Solar Distribution

Access to rooftop solar is not distributed evenly across income brackets in Minnesota. **Figure 16** shows that rooftop solar adoption in low-income communities significantly lags behind solar adoption among higher income households. Less than five percent of rooftop solar adopters are in the lowest-income quintile, while more than 40 percent of rooftop solar adopters are in the highest-income quintile.

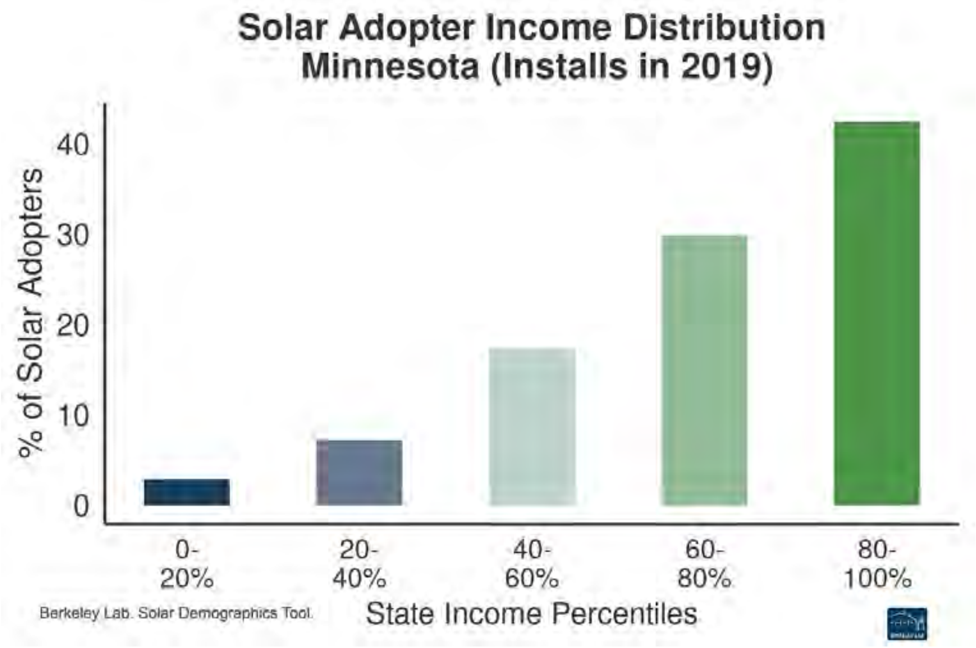

Figure 16. Rooftop solar adoption by income bracket in Minnesota.[87]

Low-income solar programs, such as community solar with virtual net metering, can enable subscribers who otherwise face substantial barriers to rooftop solar adoption to benefit from solar. In addition, when residential or community solar is coupled with energy storage systems, additional resilience benefits can be attained such as in the case of power outages. Resilience benefits may be particularly valuable in communities with frequent power outages, rural areas, and places facing climate disruption, and even more so for vulnerable populations, such as the elderly and those reliant on electricity to support medical equipment.

Minnesota Power's Low-Income Solar Program aims to create a long-term solar market for low-income customers. Its dedicated funding recently increased to $120,000 per year from 2021-2024 as the program moved out of the pilot phase,[88] but additional funding will be needed to reach a significant share of low-income households. Additional investments to fund a substantial increase in the number of community solar projects can help reduce electricity costs for a significantly larger pool of low-income customers.

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[87] Image Source: Berkeley Lab. (2021). Solar Demographics Tool.

[88] Minnesota Power. (2022). Minnesota Power's Low Income Solar Program.

4. Key Findings and Discussion

Our analysis holds several key implications for the Minnesota Power IRP.

Boswell Energy Center: Under MP's 2021 Plan, Unit 3 at the Boswell Energy Center is expected to run through 2029, and Unit 4 through 2035, contributing to an approximate $PM_{2.5}$-related mortality impact of 47 individuals over 15 years from 2021-2035 (an average of three deaths per year). These health impacts fall disproportionately on Native populations by a factor of three. Based on historic water usage and coal ash disposal on site—in ponds near monitoring wells which have recorded pollutant exceedances of federal standards for numerous pollutants including arsenic—the plant is expected to dispose of 6,240 tons of waste and consume 7.1 billion gallons of water from 2021-2035. The plant is also located in a disproportionately low-income community with high cumulative socioeconomic burdens. Retiring Unit 3 by 2025 and Unit 4 by 2030 would save approximately 17-19 lives, reduce adverse health impacts by approximately $200 million, reduce on-site disposal of 2,260 tons of waste, and save approximately 2.6 billion gallons of water.

Hibbard Energy Center: The magnitude of public health impacts of the Hibbard Energy Center are somewhat uncertain given changes in mill ownership and an unknown future distribution of electricity and steam generation at this plant. However, the biomass and coal combustion at the plant is associated with relatively high health impacts, and the ongoing use of this plant for any purpose will continue to have these health impacts. Moreover, it is the most urban power plant of those analyzed, and the nearby populations are disproportionately low-income and face high cumulative socioeconomic burdens. The ongoing use of Hibbard in MP's 2021 Plan means ongoing air pollutant emissions in this community, affecting those nearby and across the region.

Milton R. Young: Although located in North Dakota, Milton R. Young's emissions have significant health impacts in Minnesota as well as across the whole region. Milton R. Young's emission rates are higher for most pollutants than Boswell's, and the portion of electricity contracted for by Minnesota Power alone is modeled to cause roughly 3.5 mortalities per year. The decision in MP's 2021 Plan to reduce reliance on this plant may contribute to lower emissions if there are no other electricity off-takers, which would have great public health benefits across the region, in addition to reducing greenhouse gas emissions, local water consumption, and coal ash waste disposal. However, these reductions will not be realized if new long-term contracts support ongoing coal combustion at Milton R. Young.

NTEC: The proposed NTEC facility is located in a relatively low-income community with a higher number of people living nearby than any other facility analyzed except Hibbard. Moreover, the carbon dioxide emissions associated with future gas combustion at this facility only represent about half of the greenhouse gas impacts of this plant in the near term: inclusion of nitrous oxide emissions and upstream fugitive methane associated with gas production, processing, and transmission suggests that the total climate impacts of the facility will be nearly double the direct CO_2 emissions over a 20-year timeframe. In addition, gas production is associated with the emissions of health-damaging air pollutants that can pose risks to communities living near gas production sites. Finally, if NTEC is required to retire early in a gas-constrained future—or grows increasingly expensive with future greenhouse gas pricing or natural gas price volatility—it may pose a risk as an expensive or stranded asset, and there is a risk these costs would get passed on to customers and exacerbate energy affordability concerns.

Energy Equity: Energy cost burdens within Minnesota Power territory are substantially higher in low-income census tracts with a high share of renters and a higher share of Black residents. These low-income areas and populations can benefit from energy-saving measures to help reduce energy cost burden inequities. Historically, MP's energy efficiency investments in low-income communities have averaged 20 percent of total residential efficiency investments and projected low-income energy savings are only 13 percent of total projected residential energy savings. These numbers are not proportional to the share of the low- and moderate-income population in Minnesota Power territory, which we estimate to be around 30 percent of the total population. In order to achieve a meaningful reduction in energy cost burdens within its territory, Minnesota Power will need to adopt the Very High efficiency scenario with a provision that at least one third of all projected energy savings are attained in low-income households. We estimate that this will more than quadruple the number of low-income households adopting energy-saving and bill-reducing measures annually. In addition, Minnesota Power should invest significantly more in expanding rooftop and community solar programs that provide affordable electricity to low- and moderate-income households. Transparent data sharing for these programs would also enable more robust analysis to identify and mitigate energy cost burdens.