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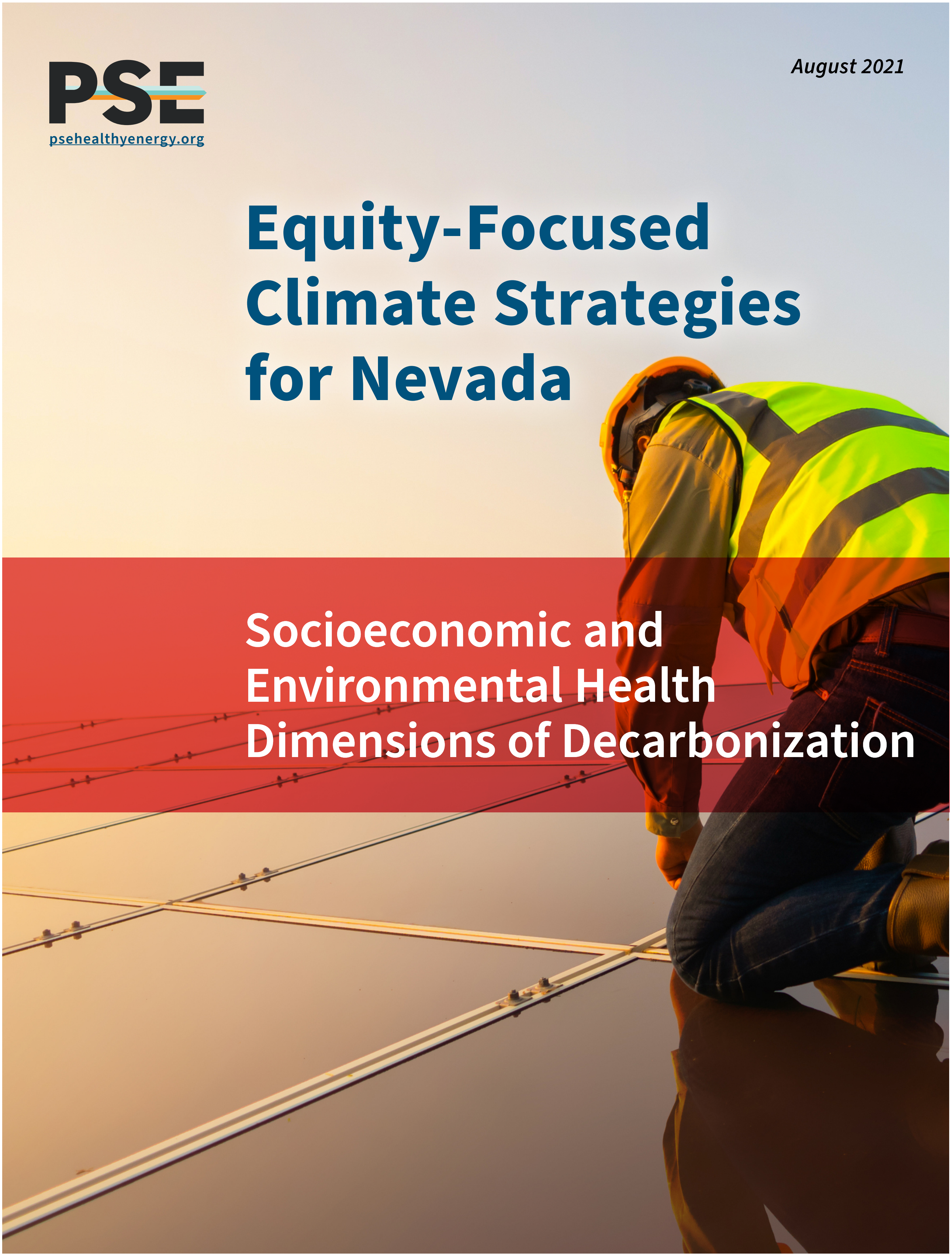
Equity-Focused Climate Strategies for Nevada

Socioeconomic and Environmental Health Dimensions of Decarbonization



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About PSE Healthy Energy

Physicians, Scientists, and Engineers for Healthy Energy (PSE) is a multidisciplinary, non-profit research institute that studies the way energy production and use impact public health and the environment. We share our work and translate complex science for all audiences. Our headquarters is located in Oakland, California.

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1. Introduction and Background

1.1 Motivation

In the face of a warming climate and associated impacts, the State of Nevada is embarking on an ambitious multi-decade effort to dramatically cut carbon emissions while confronting a growing need to build climate resilience. In 2019, the State set targets to expand renewable electricity generation while slashing economy-wide greenhouse emissions. It is now developing pathways and policies to achieve these goals.

Nevada's current fossil fuel-based energy infrastructure, however, is not only a source of greenhouse gas emissions, but also releases emissions of health-damaging air pollutants across the state. Furthermore, low-income households often struggle to pay for the electricity and fuels they rely on to power their homes and vehicles. People of color historically face racialized discriminatory practices such as housing redlining, and lack of capital and access to financing for homeownership and energy efficiency upgrades. Renters, a substantial population in Nevada, depend on landlords for clean and efficient appliances and homes. These and many other social inequities impact every sector of the economy, and decarbonization efforts should consider these existing disparities in order to develop clean energy transition strategies that distribute benefits more evenly across the Nevada population.

In this report, we use the phrase *energy equity* to encompass the participation and inclusion of historically marginalized populations in the energy economy—including energy ownership, production, and use—in order to shape energy policy that is more equitable, accessible, and economically beneficial.[1,2] In parallel, *environmental equity* ensures that no population faces a disproportionate share of environmental pollution and that all populations have access to the benefits of a clean environment and an opportunity to participate in the environmental policy decision-making process.[3]

As Nevada reshapes its energy system to reduce greenhouse gas emissions, it simultaneously has a unique opportunity to address the disproportionate environmental public health and economic burdens the current energy system places on the Nevada population. However, if these considerations are not incorporated at the outset, these co-benefits may not be fully realized and some inequities may be exacerbated. In this analysis, we assess opportunities and strategies to integrate pollution reduction, resilience, and energy and environmental equity into the state's decarbonization plans, with a focus on Nevada's most environmentally burdened and socioeconomically vulnerable communities.

To better understand the technical approaches Nevada could follow to achieve its climate targets, Evolved Energy Research—working with Sierra Club, NRDC, and GridLab—recently modeled four potential decarbonization pathways from 2020-2050.[4] These pathways rely on energy efficiency, renewable energy, city and transportation planning, and electrification measures to reduce fossil fuel use in buildings, transportation, power generation, and industry. While the *locations* of greenhouse gas emission sources are not important from a climate perspective, many greenhouse gases are co-emitted with health-damaging air pollutants. As such, in this report, we add spatial

1 US Department of Energy. Office of Economic Impact and Diversity. The Equity in Energy Initiative (2020).

2 California Energy Commission. SB 350 Barriers Study (2016).

3 US Environmental Protection Agency. Environmental Equity: Reducing Risk for All Communities (1992).

4 Dylan Sullivan *et al.* Pathways and Policies to Achieve Nevada's Climate Goals: An Emissions, Equity, and Economic Analysis. *Evolved Energy, GridLab, NRDC, and Sierra Club* (2020).

dimensions to these techno-economic statewide decarbonization pathways to better understand the ways in which climate policy could reduce, not impact, or exacerbate energy cost burdens, health-damaging air pollutant emissions, and climate impacts in different communities throughout the state.[5]

Rapid and effective decarbonization across economic sectors is a critical step to the protection of the climate and the health and safety of all communities. However, it is important to note that a reduction in greenhouse gas emissions alone can facilitate, but does not guarantee, a concurrent decrease in emissions of health-damaging air pollutants,[6] nor does it necessarily reduce cost burdens of energy access in any one community.[7] Moreover, recent research has found that even though overall air pollution levels have declined nationwide, disparities in exposure between neighborhoods have persisted for decades.[8] As such, it is advisable that solutions to existing environmental pollution and energy cost burden disparities should be explicitly engineered into decarbonization policies to ensure that benefits of this transition are both rapidly and equitably realized.

Decarbonization strategies that prioritize emission and cost burden reductions in places where carbon-intensive infrastructure also emits health-damaging air pollutants, where households struggle to afford their energy bills, or lack access to clean energy technologies would generate more equitable health and economic outcomes than policies focused exclusively on carbon equivalent emission reductions irrespective of location and demographics. Equitable strategies might include targeted efficiency and electrification measures for low-income households, for example, or the electrification of heavy-duty equipment in polluted industrial neighborhoods.

To establish an analytical framework to make decarbonization pathway decisions that simultaneously address social and health disparities we undertake the following:

1. Identify regions and populations currently facing high cumulative pollutant emissions (i.e. multi-source, multi-pollutant emissions) from fossil fuel production and use.
2. Characterize household and transportation energy cost burdens and clean energy access across the state.
3. Identify decarbonization strategies that simultaneously reduce health-damaging air pollution and energy cost burdens while increasing climate resilience.

After discussing our findings and conclusions, we provide actionable policy and research recommendations that emerge from our analyses.

5 An economy-wide clean energy transition away from fossil fuels will also have job impacts in some sectors and communities and provide workforce development opportunities in others. These workforce considerations will be addressed in a forthcoming companion report in Spring 2021.

6 Smith, Kirk R., *et al.* Public Health Benefits of Strategies to Reduce Greenhouse-Gas Emissions: Health Implications of Short-Lived Greenhouse Pollutants. *The Lancet.* 374.9707 (2009): 2091-2103.

7 Shonkoff, Seth B., *et al.* The Climate Gap: Environmental Health and Equity Implications of Climate Change and Mitigation Policies in California—A Review of the Literature. *Climatic Change* 109.1 (2011): 485-503.

8 Colmer, Jonathan, *et al.* Disparities in $PM_{2.5}$ Air Pollution in the United States. *Science* 369.6503 (2020): 575-578.

1.2 Background

Worldwide, the planet's average surface temperature has warmed approximately 2˚F since the late 1800s,[9] but this warming is unevenly distributed; average temperatures in Las Vegas, for example, have increased nearly 6˚F since just 1970.[10] Heat-related deaths in Las Vegas have been increasing along with this temperature growth.[11] In 2020, most regions of Nevada—from Clark County to Douglas County to Elko County—measured their warmest August on record.[12] The state faced more than five years of continuous drought from late 2011-2017, and as of late 2020, nearly the entire state is once again facing drought.[13] The state is projected to face an increasing number of extreme heat days,[14] growing wildfire threats, and drought[15] in the coming decades, in addition to changes in weather and precipitation patterns.

To help mitigate climate change, Nevada has committed to transitioning away from fossil fuels and reducing economy-wide greenhouse gas emissions by 2050 through a combination of renewable portfolio standards (Senate Bill [SB] 358)[16] and greenhouse gas reduction targets (SB 254).[17] The state's core climate goals are summarized in **Table 1**.

Governor Steve Sisolak expanded on these goals with Executive Order 2019-22[18] and subsequently launched the State of Nevada Climate Initiative in 2020.[19] As directed by this Executive Order, the State is now required to develop its climate change mitigation strategy in a way that considers its impacts on low-income and disadvantaged communities in Nevada. Consideration of the broader societal impacts of climate strategy is valuable; decarbonization planning nationwide frequently fails to account for public health, environmental impacts, and social equity. Models that do take health impacts into account, however, find that it is possible to increase health co-benefits by prioritizing them alongside decarbonization goals. Incorporating

TABLE 1. Key Nevada climate targets.

Category	Year	Target
Statewide greenhouse gas reductions	2025	28% below 2005 levels
	2030	45% below 2005 levels
	2050	Net-zero greenhouse gas emissions
Electricity generation	2030	50% renewable electricity
	2050	100% zero-carbon (goal)

9 NASA Jet Propulsion Laboratory. Global Climate Change: Vital Signs of the Planet. Oct. 2, 2020.

10 Climate Central. American Warming: The Fastest-Warming Cities and States in the U.S. Apr. 17, 2019.

11 Bandala, E. R., *et al*. Extreme Heat and Mortality Rates in Las Vegas, Nevada: Inter-Annual Variations and Thresholds." *International Journal of Environmental Science and Technology* 16.11 (2019): 7175-7186.

12 NOAA National Centers for Environmental information, "Climate at a Glance: County Time Series." Accessed: Sept. 2020. Available at: https://www.ncdc.noaa.gov/cag/

13 National Integrated Drought Information System. "Drought in Nevada." Last accessed: Nov. 3, 2020. Available at: https://www.drought.gov/drought/states/nevada

14 Climate Impact Lab, "Climate Impact Map." 2020. Available at: http://www.impactlab.org/map/

15 NASA's Scientific Visualization Studio. Megadroughts in U.S. West Projected to be Worst of the Millennium. Feb. 12, 2015.

16 Nevada 80th Legislative Session. SB 358 (2019).

17 Nevada 80th Legislative Session. SB 254 (2019).

18 Governor Steve Sisolak. Executive Order 2019-22 (2019).

19 State of Nevada Climate Initiative. "Gov. Sisolak Launches New State of Nevada Climate Initiative." Aug. 2020. Available at: https://climateaction.nv.gov/news/gov-sisolak-launches-new-state-of-nevada-climate-initiative/

health co-benefits not only improves societal wellbeing, but can improve the cost-effectiveness of decarbonization by reducing medical expenditures associated with the health impacts of air pollution.[20]

For example, Driscoll *et al.* (2015) found that power sector decarbonization policies emphasizing demand-side energy efficiency yielded the greatest public health benefits,[21] and Fann *et al.* (2011) illustrated strategies to maximize health benefits and reduce inequality in pollution burdens by focusing on multi-pollutant reductions in vulnerable communities.[22] These examples illustrate a few possible ways to build energy and environmental equity into decarbonization plans, although there are many ways in which energy systems intersect with such considerations. Below, we summarize the primary public health and social equity frameworks underlying this report.

Public Health

The use of fossil fuels in buildings, power plants, transportation, and industry —as well as the production of fossil fuels and, of more direct importance in Nevada, mining of materials for energy production and storage technologies—can contribute to a wide array of public health impacts, most directly through air and water pollution. This report uses air pollutant emissions as its primary indicator of public health hazards and risks due to publicly available air pollution emissions data and the corresponding ease of comparing air pollutant data across sectors. Air pollution impacts on human health result from both the emissions of primary pollutants, such as criteria air pollutants including particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and volatile organic compounds (VOCs). Additional health impacts occur from secondary formation of air pollutants (ozone and $PM_{2.5}$) in the atmosphere from precursors like nitrogen oxides, SO_2, and VOCs.

The health impacts of PM, NO_x, SO_2, and ground-level ozone are well-established and are included in a class of criteria air pollutants regulated through the National Ambient Air Quality Standards set by the US Environmental Protection Agency (EPA).[23] Acute and chronic exposure to ozone and $PM_{2.5}$ are associated with adverse cardiovascular and respiratory health outcomes such as asthma and heart attacks, as well as other poor health outcomes including premature mortality.[24] NO_2 and SO_2 are associated with respiratory irritation and difficulty breathing, in addition to their roles alongside other NO_x and SO_x compounds as ozone and $PM_{2.5}$ precursors.[25,26] In addition to criteria air pollutants such as those listed above, EPA regulates hazardous air pollutants, including some VOCs, typically due to their potential for cancer and other serious health effects.[27]

The health impacts of emissions from the combustion of fossil fuels tend to be most elevated for those living near and downwind from these activities, but can also extend across broader regions, hundreds of miles from the pollution source. Conversely, exposure can also be very localized. For example, residential combustion of natural gas, propane, fuel oil, and wood for heating, cooking, and other domestic uses can contribute to elevated concentrations of air pollutants and exposure via poor indoor air quality.[28,29]

20 Scovronick, Noah, *et al.* The Impact of Human Health Co-Benefits on Evaluations of Global Climate Policy. *Nature Communications* 10.1 (2019): 1-12.

21 Driscoll, Charles T., *et al.* US Power Plant Carbon Standards and Clean Air and Health Co-Benefits. *Nature Climate Change* 5.6 (2015): 535-540.

22 Fann, Neal, *et al.* Maximizing Health Benefits and Minimizing Inequality: Incorporating Local-Scale Data in the Design and Evaluation of Air Quality Policies. *Risk Analysis: An International Journal* 31.6 (2011): 908-922.

23 US Environmental Protection Agency. “Criteria Air Pollutants” (2020). Available at: https://www.epa.gov/criteria-air-pollutants

24 Pope III, C. Arden, and Douglas W. Dockery. Health Effects of Fine Particulate Air Pollution: Lines that Connect. *Journal of the Air & Waste Management Association* 56.6 (2006): 709-742.

25 US Environmental Protection Agency. “Nitrogen Dioxide Pollution.” Sept. 8, 2016. Available at: https://www.epa.gov/no2-pollution/basic-information-about-no2#Effects

26 US Environmental Protection Agency. “Sulfur Dioxide Pollution” (2019). Available at: https://www.epa.gov/so2-pollution/sulfur-dioxide-basics#effects

27 US Environmental Protection Agency. “Health and Environmental Effects of Hazardous Air Pollutants” (2017). Available at: https://www.epa.gov/haps/health-and-environmental-effects-hazardous-air-pollutants

28 Seals, Brady and Andee Krasner. Health Effects from Gas Stove Pollution. *Rocky Mountain Institute* (2020).

29 Semmens, Erin O., *et al.* Indoor Particulate Matter in Rural, Wood Stove Heating Homes. *Environmental Research* 138 (2015): 93-100.

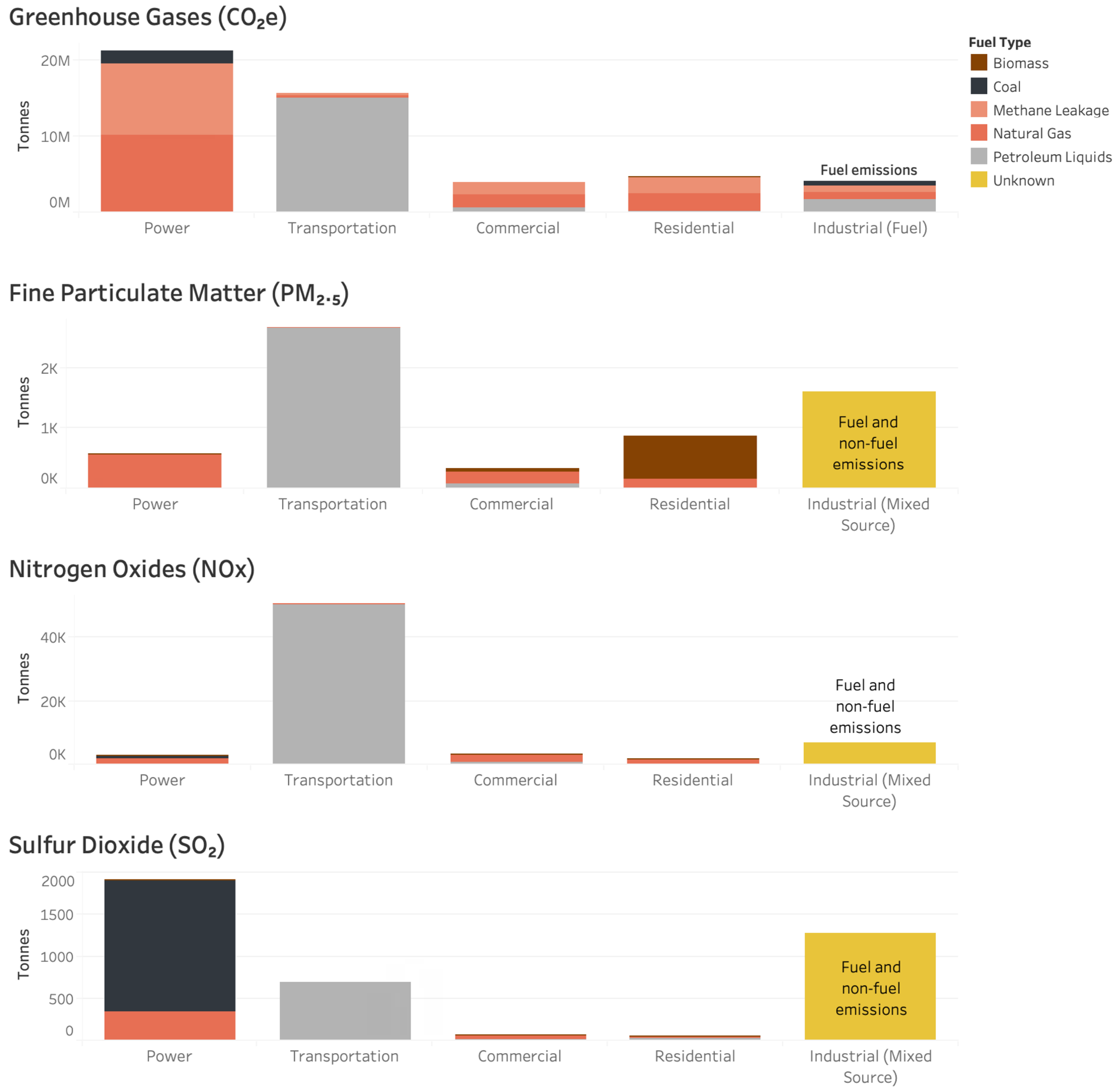
Primary pollutant emissions and estimated upstream methane emissions, primarily associated with fossil fuel use across Nevada's commercial, industrial, power, residential, and transportation sectors, are shown in **Figure 1**. As noted above, many of these primary pollutants also contribute to the secondary formation of ozone and particulate matter. Direct emissions of carbon dioxide (CO_2) do not fully reflect the lifecycle greenhouse gas emissions of fossil fuel use, most notably the leakage of methane, a potent greenhouse gas, throughout the natural gas system. We therefore estimated the greenhouse gas equivalent impact of methane leakage throughout the production, processing, transmission, and use of natural gas to better reflect the lifecycle climate impacts of gas use in Nevada. Methane leakage is estimated to increase the radiative forcing (a measure of global warming impact) of the CO_2 released directly from natural gas combustion by 92 percent over a twenty-year time period,[30] which is plotted in CO_2-equivalent (CO_2e) in **Figure 1.**[31]

The sectors in **Figure 1** reflect the majority of the state's energy consumption and associated emissions and we use these sectors to categorize emissions in a way that is pertinent to the structure of decarbonization policies. We use this sectoral framework throughout this report. It is important to note the wide variability in pollutant emissions by sector and fuel type, illustrating that a focus on carbon dioxide emissions reduction can achieve very different co-pollutant reduction benefits depending on the sector.

30 Alvarez, Ramón A., *et al.* Assessment of Methane Emissions from the US Oil and Gas Supply Chain. *Science* 361.6398 (2018): 186-188.

31 Distribution-level leakage rates, including behind-the-meter, still have significant uncertainty and may be higher than assumed by the State of Colorado, but a deeper discussion of methane leakage rates and uncertainties is beyond our scope here.

FIGURE 1. Nevada's cross-sector primary emissions of select criteria air pollutants by fuel type and lifecycle greenhouse gas emissions including primary carbon dioxide and upstream methane leakage.[32,33,34] Industrial criteria air pollutant emissions include fuel- and non-fuel emissions from stationary point sources.[35] Methane leakage estimates use a 20-year global warming potential and a leakage rate of 2.9 percent of end-use gas consumption.[36] The variation in co-pollutant emissions indicates that the reduction of greenhouse gases from different sectors will have different impacts on criteria air pollutant reductions.



32 Coal generation fell 13 percent between 2017 and 2019, somewhat reducing coal-related emissions in recent years.

33 Data includes internal modeling and the following sources: US Environmental Protection Agency, "National Emissions Inventory (NEI)" (2017), available at: https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei; US Energy Information Administration, "Energy-Related CO_2 Emission Data Tables," available at: https://www.eia.gov/environment/emissions/state/; US Energy Information Administration, "Emissions by Plant and by Region," available at: https://www.eia.gov/electricity/data/emissions/

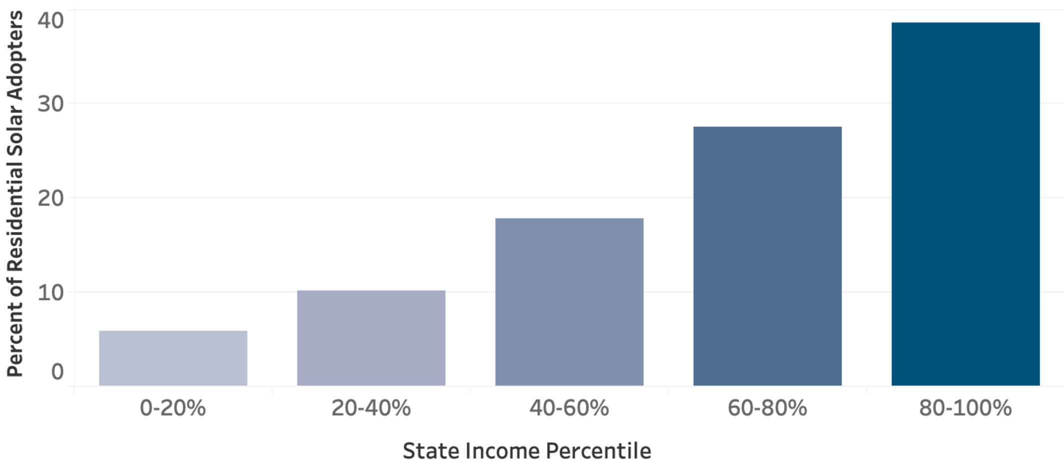
34 While many nonroad mobile sources serve industrial facilities, we include these sources in the transportation sector as they likely require similar technical and policy solutions to on-road vehicles in terms of vehicle electrification and electric vehicle charging infrastructure.

35 NEI emissions estimates for industrial nonpoint sources may be underestimates, as a result of underreporting of pipeline emissions between wellheads and gas processing facilities, as well as the existence of above-average high-emitting oil and gas sites (Grant, John *et al*. U.S. National Oil and Gas Emission Inventory Improvements. (2017)).

36 Alvarez, Ramón A., *et al.* Assessment of Methane Emissions from the US Oil and Gas Supply Chain. *Science* 361.6398 (2018): 186-188.

Low-income communities, communities of color, and other socioeconomically and demographically vulnerable groups across the country disproportionately live near fossil fuel infrastructure and are exposed to an inordinate share of its pollution. Studies have found, for example, that communities of color are disproportionately exposed to air pollution,[37] including from fossil fuel sources like transportation,[38] and communities with high socioeconomic burdens are more likely to live near fossil fuel infrastructure, such as power plants.[39,40] Living near facilities such as power plants is associated with adverse health effects such as respiratory disease[41] and adverse birth outcomes.[42,43] Additionally, some vulnerable populations, such as young children, the elderly, and those with pre-existing medical conditions, are particularly sensitive to health impacts from environmental pollution.[44] Decarbonization efforts,[45] such as power plant retirements of electrification of indoor gas appliances, have the potential to reduce fossil fuel co-pollutant exposures and health impacts for these communities and populations.[46]

FIGURE 2. Residential adoption by Nevada state income percentiles in 2018.[47] The highest-income 20 percent of households were responsible for 39 percent of solar installations, as compared to six percent of solar installations among the 20 percent lowest-income households.



37 Tessum, Christopher W., *et al.* Inequity in Consumption of Goods and Services Adds to Racial–Ethnic Disparities in Air Pollution Exposure. *Proceedings of the National Academy of Sciences* 116.13 (2019): 6001-6006.

38 Clark, Lara P., *et al*. Changes in Transportation-Related Air Pollution Exposures by Race-Ethnicity and Socioeconomic Status: Outdoor Nitrogen Dioxide in the United States in 2000 and 2010. *Environmental Health Perspectives* 125.9 (2017): 097012.

39 Krieger, Elena M., *et al*. 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 (2016): 302-313.

40 EPA, "EJ Screening Report for the Clean Power Plan," US Environmental Protection Agency, Tech. Rep.Docket: EPA–HQ–OAR–2013–0602, (2015).

41 Liu, Xiaopeng, *et al*. Association Between Residential Proximity to Fuel-Fired Power Plants and Hospitalization Rate for Respiratory Diseases. *Environmental Health Perspectives* 120.6 (2012): 807-810.

42 Ha, Sandie, *et al*. Associations Between Residential Proximity to Power Plants and Adverse Birth Outcomes. *American Journal of Epidemiology* 182.3 (2015): 215-224.

43 Casey, Joan A., *et al*. Retirements of Coal and Oil Power Plants in California: Association with Reduced Preterm Birth Among Populations Nearby. *American Journal of Epidemiology* 187.8 (2018): 1586-1594.

44 Pope III, C. Arden, and Douglas W. Dockery. Health Effects of Fine Particulate Air Pollution: Lines that Connect. *Journal of the Air & Waste Management Association* 56.6 (2006): 709-742.

45 However, improper deployment of certain measures, such as energy efficiency without proper ventilation, can also result in negative health impacts. See, for example: Underhill, Lindsay J., *et al.* Simulation of Indoor and Outdoor Air Quality and Health Impacts Following Installation of Energy-Efficient Retrofits in a Multifamily Housing Unit. *Building and Environment* 170 (2020): 106507.

46 Martenies, Sheena E., *et al*. Health and Environmental Justice Implications of Retiring Two Coal-Fired Power Plants in the Southern Front Range Region of Colorado. *GeoHealth* 3.9 (2019): 266-283.

47 Data source: Berkeley Lab. "Solar Demographics Tool" (2020). Available at: https://emp.lbl.gov/solar-demographics-tool

Assessments of cumulative environmental burdens and socioeconomic vulnerabilities can help identify populations for whom interventions to reduce pollution may be particularly beneficial.[48] For example, California uses an environmental justice screening tool, CalEnviroScreen 3.0,[49] to define and identify disadvantaged communities and develop incentives to increase clean energy access and reduce pollution burdens for these populations. The US EPA has also developed an environmental justice screening tool, EJSCREEN, to identify similar highly polluted and socioeconomically vulnerable communities nationwide.[50]

Energy Cost Burdens and Clean Energy Access

Residential and transportation energy use can contribute to high utility and fuel bills, which weigh particularly heavily on energy cost-overburdened populations such as lower income households or households of color. For example, although lower-income households tend to pay less in total magnitude for energy than higher-income households, they spend a larger fraction of their paycheck on energy use. They also tend to live in less efficient homes and drive less efficient vehicles. The American Council for an Energy Efficient Economy estimates that low-income households (<double federal poverty line) in the Las Vegas metropolitan area spend a median 6.5 percent of their income on residential energy bills, and a quarter of low-income households spend 13.8 percent; as compared to 2.8 percent for the average household.[51] The median Black and Latino households in the Las Vegas metropolitan area spend 3.2 percent and 3.0 percent of their income on energy bills, respectively. Moreover, low-income and other vulnerable households may struggle to pay fluctuating bills, face the risk of utility shutoffs, and struggle with energy insecurity, which can exacerbate underlying health conditions[52] and reduce resilience to climate extremes.

Certain clean energy interventions can help alleviate energy cost burdens. Residential efficiency and weatherization measures, for example, can reduce electric bills and the need for heating and cooling. Rooftop solar or community solar (if permitted) can provide long-term economic savings and stable electric bills. Unfortunately, low-income households and people of color often face barriers to adoption for these kinds of technologies. Some technologies, such as air source heat pumps, solar panels, or electric vehicles, are capital-intensive. They may be cheaper over the lifetime of the equipment, but lower income households often lack access to capital, financing, or credit that makes these investments accessible, and may be vulnerable to scams.[53] Additionally, many households may be linguistically isolated or lack access to information that energy-saving technologies are available. As many people of color and low-income families live in rental apartments, their ability to replace appliances or adopt efficiency measures in their homes is limited. This barrier is termed the split incentive problem, wherein renters pay utility bills but landlords own energy sources and appliances and have limited financial incentives to invest in efficiency measures. In addition, some clean energy measures—such as energy efficiency—may reduce average bills but may also contribute to higher electricity rates. While average energy bills may go down, other households which do not adopt energy-savings measures may face higher bills. Due to the aforementioned barriers, low-income households are at particular risk for such utility bill increases.

The impact of these kinds of barriers is reflected in rooftop solar adoption rates across Nevada. **Figure 2** shows solar adoption rates by income bracket in 2018. The wealthiest 20 percent of households adopted rooftop solar at more than six times the rate of the lowest-income 20 percent of households.

48 Sadd, James L., *et al.* Playing It Safe: Assessing Cumulative Impact and Social Vulnerability through an Environmental Justice Screening Method in the South Coast Air Basin, California. *International Journal of Environmental Research and Public Health* 8.5 (2011): 1441-1459.

49 California Office of Environmental Health Hazard Assessment. "CalEnviroScreen 3.0." Available at: https://oehha.ca.gov/calenviroscreen

50 US Environmental Protection Agency. "EJSCREEN." Available at: https://www.epa.gov/ejscreen

51 Drehobl, Ariel *et al.* How High are Household Energy Burdens? *American Council for an Energy Efficient Economy,* (2020).

52 Hernández, Diana, and Stephen Bird. Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy. *Poverty & Public Policy* 2.4 (2010): 5-25.

53 Schulz, Bailey. Reports of Solar Scams on the Rise in Las Vegas Valley. *Las Vegas Review-Journal.* June 10, 2019.

1.3 Approach

In this assessment, we examined current environmental and energy cost burdens and socioeconomic and racial disparities across the Nevada population and how different approaches to decarbonization may increase or decrease these burdens. We relied on a variety of publicly available datasets that enabled us to evaluate the type, magnitude, and geography of energy use, environmental pollution, and the distribution of costs and benefits across demographic groups in Nevada. To inform our technical analyses, we also conducted extensive statewide outreach with various nongovernmental organizations, advocacy groups, and other community organizations. This outreach enabled us to identify key topics, concerns, and priorities. This analysis is meant to provide an initial screen of pollution and energy cost burdens and identify policy levers to intervene and approaches to integrate energy and environmental equity into decarbonization research and policy moving forward. The development of energy equity and pollution-focused policies should also include extensive engagement and outreach to affected communities to help identify concerns and barriers and develop policies reflecting community needs and priorities.

We first mapped existing fossil fuel infrastructure and energy-related pollutant emissions across the commercial, residential, transportation, industrial, and power sectors, and analyzed the demographics of nearby populations. Next, we estimated average baseline residential and transportation energy cost burdens for households across the state. We applied Evolved Energy's four decarbonization scenarios (see below) to these baseline pollution and energy consumption data to assess impacts on pollution and energy bills in relation to spatial and socioeconomic indicators.

Decarbonization Scenarios

Evolved Energy Research developed cost-optimized decarbonization pathways using a combination of two energy system analysis platforms: EnergyPATHWAYS, a bottom-up energy sector model which calculates future energy demand; and the Regional Investment and Operations (RIO) platform, which optimizes costs while ensuring demand is reliably met. Together, these models estimate future energy use, appliance and vehicle turnover, electricity generation and demand, greenhouse gas emissions, and costs from 2020-2050. Importantly, in Evolved Energy's models and throughout our accompanying analysis, estimated energy consumption and greenhouse gas and criteria air pollutant emissions in the year 2020 do not reflect the impacts of COVID-19 on energy production and use.

Evolved Energy Research assessed five scenarios, including a reference "business-as-usual" scenario and four additional scenarios ensuring each state achieves its climate targets. These scenarios are outlined in **Table 2**. For a full description of Evolved Energy Research's scenarios, as well as underlying models, assumptions and inputs, please see the accompanying report by Evolved Energy Research, GridLab, Natural Resources Defense Council (NRDC), and Sierra Club.[54]

Integrating Health and Energy Equity Analysis

Our initial environmental and energy cost burden analysis provides a baseline for us to identify areas where clean energy adoption and emissions reductions might be particularly valuable to reduce pollution or energy cost burdens in socioeconomically or environmentally overburdened communities. To create this baseline, we aggregated public datasets reporting fossil fuel emissions from power plants and industrial facilities, estimated transportation emissions from highway vehicle counts and standard vehicle emission factors, and conducted a statistical analysis which estimated residential fuel use on a census tract level based on household and geographic characteristics. In addition to calculating emissions, we estimated household energy cost burdens based on these fuel consumption estimates.

54 Dylan Sullivan, *et al*. Pathways and Policies to Achieve Nevada's Climate Goals: An Emissions, Equity, and Economic Analysis. *Evolved Energy, GridLab, NRDC, and Sierra Club* (2020).

TABLE 2. Description of decarbonization scenarios.[55]

Scenario	Description
Reference	State implements no new climate policies and does not achieve greenhouse gas targets.
Core	Central cost-optimized decarbonization pathway, relying primarily on near-term decarbonization of the power sector and retirement of coal plants, combined with building efficiency and electrification of transportation and fuel use in buildings and industry.
Low Demand	Energy demand is lower than in the core scenario due to lower vehicle miles traveled (e.g. due to public transit or behavioral changes) and more energy efficiency in buildings.
Fossil Free	Current state greenhouse gas targets are surpassed and fossil fuel production, extraction, and use is eliminated by 2050.
Slow Coal Retirement	Decarbonization of the power sector lags behind the core scenario, requiring more rapid adoption of energy efficiency and electrification measures across the building and transportation sectors to ensure 2030 climate targets are met.

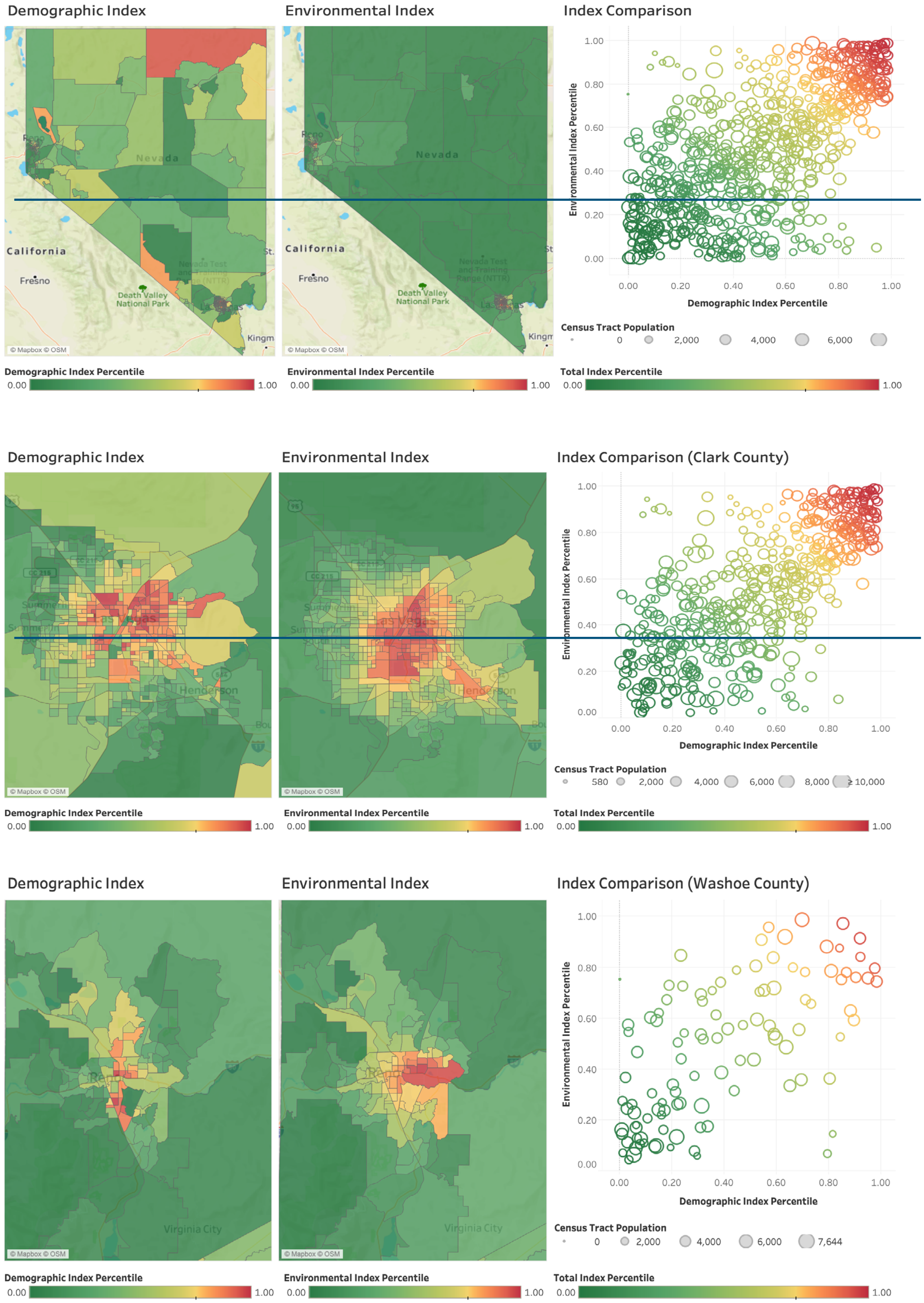
To identify Nevada communities that may be particularly vulnerable to the impacts of air pollution, we analyzed demographic characteristics of populations across the state. From this analysis we screened for census tracts that have comparatively high socioeconomic burdens as compared to other census tracts in Nevada. As part of this screen, we developed a Demographic Index for Nevada census tracts, based largely on US EPA's EJSCREEN demographic data, which combines measures on low-income households,[56] education, linguistic isolation, very young, elderly, and racial minority populations (see **Technical Appendix: Methods**). We then used this index to assess where socioeconomically overburdened communities are also exposed to high environmental pollution or have high energy cost burdens. We also created an Environmental Index, based on certain metrics such as ground-level ozone and particulate matter concentrations, proximity to hazardous facilities and polluted sites, and other pollution measures.

In **Figure 3**, we show the Demographic Index and Environmental Index for Nevada, as well as a closer look at Washoe and Clark Counties. These maps reflect a mix of socioeconomically overburdened populations in both urban and rural communities, and highlight a number of highly polluted neighborhoods in Las Vegas and Reno. The plot on the right shows a strong correlation between communities with high cumulative pollution and socioeconomic burdens. To explore pollution trends, we use select demographic indicators to assess relationships between specific pollutant sources (e.g. on-road vehicles) and population characteristics across Nevada.

55 The scenario names used in this report differ from those used in the companion report Pathways and Policies to Achieve Nevada's Climate Goals: An Emissions, Equity, and Economic Analysis. The Low Demand, Fossil Free, and Slow Coal Retirement scenarios are equivalent to the Energy Efficiency, Fossil-Free Sensitivity, and Extended Coal Sensitivity scenarios described in this companion report.

56 EJSCREEN defines "low-income" households as households below double the Federal poverty line. We use this same definition throughout our analysis, as well as defining "very low-income" households as households below the federal poverty line.

FIGURE 3. Integrated Demographic Index and Environmental Index for Nevada (top), Clark County (middle), and Washoe County (bottom). In the Demographic Index, neighborhoods that are orange or red have a higher share of combined low-income, racial minority, limited educational attainment, linguistically isolated, elderly, and very young populations than other Nevada census tracts. In the Environmental Index, neighborhoods that are orange or red have high concentrations of pollution or polluting facilities, or high excess health risk associated with pollution from numerous sources.



We note that these combined demographic indicators only reflect those measures that are included in the EJSCREEN tool, which are limited in breadth. Additional measures, such as underlying health conditions (e.g. asthma rates or preterm births) are not included in these indices but may be valuable for identifying populations sensitive to pollution. We therefore include additional indicators within some of our analyses below. These include climate indicators (e.g. wildfire and heat day risks), and environmental indicators (e.g. federal ozone nonattainment areas). These additional metrics provide more specific insight into the types of environmental vulnerabilities and burdens faced across the state. Our analysis provides an initial screen for polluted and otherwise environmentally vulnerable communities; however direct community engagement can help identify additional environmental concerns and socioeconomic burdens not available within our datasets.

By combining fossil fuel pollution and energy use data with the demographic indicators above, we identified areas where communities live near numerous sources of environmental pollution, and other communities (some overlapping) where household adoption of clean energy and transportation technologies may help provide economic and resilience benefits. We projected these baseline estimates across decarbonization scenarios and modeled where benefits might accrue — and we identified potential risks where carbon-only decarbonization policies might actually lead to negative unintended consequences such as economic impacts on socioeconomically vulnerable households. We combined these baseline and decarbonization modeling results in a discussion of policy options for Nevada to incorporate health, environment, and energy equity into its decarbonization planning.

2. **Results**

2.1 **Overview of Findings**

Across Nevada, we find that decarbonization has the potential to improve public health and reduce energy cost burdens. However, our analysis suggests that these co-benefits may not accrue evenly across the state and that disparities in fossil fuel pollution and, in particular, economic impacts may be exacerbated with a decarbonization strategy focused exclusively on carbon emissions.

In the Las Vegas metro area, as well as other Nevada cities and towns, we find that certain census tracts have a high level of health-damaging pollutant emissions, particularly from the transportation sector. Some of these areas, particularly along the interstate highways, are home to socioeconomically and demographically vulnerable populations with significant portions of populations of color and lower-income households. Switching from fossil fuels to low-emission sources has the potential to reduce much of this pollution. This approach may be particularly valuable for the Las Vegas region because it is in marginal nonattainment for federal ozone standards. In addition to vehicle electrification, we find that prioritizing the retirement of old, high-emitting trucks is critical to reducing transportation emissions in these neighborhoods in the near-term.

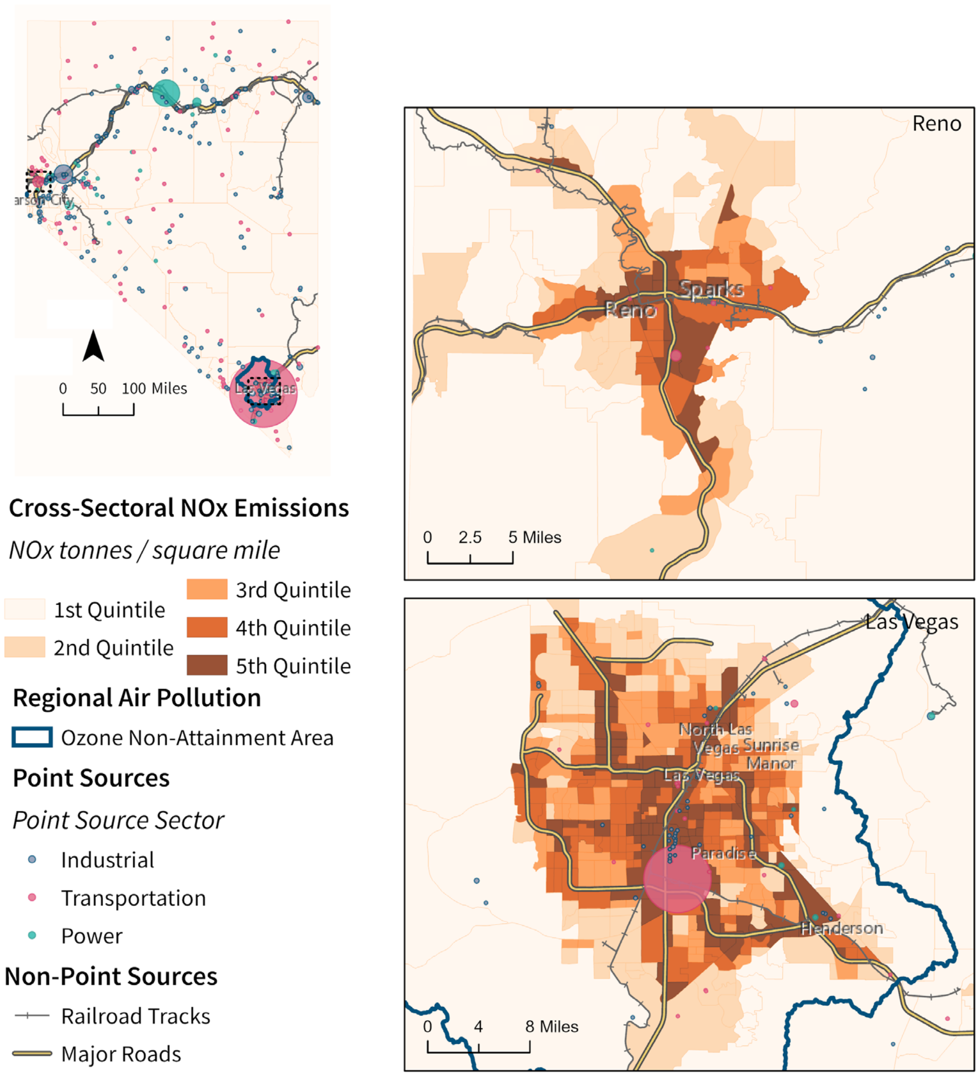
In buildings, the electrification of natural gas appliances may help reduce indoor air pollution and energy cost burdens, but due to higher barriers to adoption for many renter and low-income households, in the near term this electrification is likely to disproportionately benefit households with access to the capital necessary to buy new, efficient electric appliances. Because low-income and renter households may face financial and other barriers to clean energy adoption, electrification-related health and economic benefits are likely to accrue to wealthier and home-owning households without additional policies in place. Moreover, households which continue to use natural gas may face increased monthly bills as other households electrify their homes and the fixed costs of the gas system are distributed among fewer households—potentially leading to a scenario where households which already struggle to pay their bills are faced with increasing energy costs, notably in the post-2035 timeframe. Policies targeted at providing clean energy and electrification for these households may be particularly valuable.

Across rural Nevada and in small Nevada cities, we find that combined residential and transportation energy cost burdens are higher on average than in the state's large urban areas due to high residential utility bills and longer average driving distances.[57] Even though only a small portion of these households burn wood, those that do, contribute to a substantial share of residential pollutant emissions, including particulate matter, which can contribute to poor indoor and outdoor air quality. Residential emissions from wood burning are not currently projected to significantly change under any decarbonization pathway, unless wood use is specifically targeted for electrification in addition to natural gas.

Nevada as a whole, and Las Vegas in particular, will face increased extreme heat days and drought as the climate warms. Extreme heat regions may particularly benefit from clean energy technologies like efficiency measures to better regulate indoor temperatures and reduce energy cost burdens, as well as solar panels with battery storage (solar+storage) to provide emergency backup power in the face of increasingly frequent extreme weather events.

57 Throughout this report, "urban" refers to the Las Vegas, Reno, and Carson City US Census Bureau metropolitan statistical areas, while "rural" refers to all census tracts excluded from these categories, including micropolitan areas.

FIGURE 4. Cumulative NO_x emissions from electricity generation, buildings, transportation, and industry in 2017. Emissions per square mile are aggregated by census tract and pollutant-heavy locations such as roadways, freight yards, and power plants are shown for context, with point sources categorized by sector. Emissions are highest per unit area along urban interstates and highways, and Las Vegas Airport is Nevada's highest-emitting NO_x point source. While we do not have census tract-level data for commercial buildings, we note many of these buildings—such as casinos along the Las Vegas strip—may contribute to high cumulative emissions along major urban roadways.



In **Figure 4**, we show cumulative cross-sectoral NO_x emissions on a census tract basis, which reflects high emissions particularly along highways through Reno and Las Vegas. Decarbonization has the potential to reduce emissions like those shown in **Figure 4**, but existing disparities in emissions burdens may persist unless there are policies in place to ensure emission reductions are achieved in areas that currently have high cumulative emissions. Some of the long-term emission impacts may depend on regional decisions beyond Nevada's borders; for example, interstate truck emissions will likely depend in part on regional and national decarbonization policy, suggesting Nevada should continue to work with its neighboring states on decarbonization strategies.

There is also a risk that without explicit policies, clean energy access may lag and fossil infrastructure may be left behind in environmentally and socioeconomically overburdened communities, leaving out populations who may benefit the most from measures like efficiency savings and electrification, and potentially leaving them to shoulder the cost of maintaining an aging fossil infrastructure in the coming decades.

We walk through these findings in detail in the following sections. We first discuss our findings for each individual sector and then address cross-sectoral themes for clean energy access, emission reductions, and resilience.

2.2 Transportation

2.2.1 Transportation Sector Overview

Nevada's transportation sector—including light-duty passenger and commercial vehicles, buses, medium-duty and heavy-duty trucks, aviation, rail, and non-road vehicles[58]—is responsible for about one-third of end-use energy consumption in the state, making it the largest of Nevada's energy-consuming sectors.[59] Transportation emits nearly a third of statewide CO_2 emissions and three quarters of statewide NO_x emissions. In addition to the ground-level ozone and secondary particulate matter formed by reactions of NO_x in the atmosphere, transportation also contributes more than forty percent of primary $PM_{2.5}$ emissions statewide. Many of these emissions occur in population-dense urban areas at ground level, and can contribute to local pollution hotspots.

Decarbonization of the transportation sector is largely enabled by vehicle electrification, which reduces tailpipe pollutant emissions, though at uneven rates across the state due to different rates of electrification between vehicle classes. While we find that on-road vehicle pollution is almost entirely eliminated by 2050, ground-level airport emissions may continue to pose health risks to adjacent communities even as the rest of the sector decarbonizes. Moreover, low-income households, which include a disproportionate share of populations of color and those with low educational attainment, spend a large portion of their income on vehicle fuel but may face barriers to purchasing fuel-efficient electric vehicles such as high up-front costs and lack of access to charging infrastructure. Health and energy equity-focused decarbonization policies can help accelerate vehicle turnover in highly polluted areas, reduce barriers to adoption, and—under certain approaches—reduce vehicle use altogether by expanding access to public transit and facilitating active, transit-friendly built environments.

2.2.2 Fuel Consumption and Vehicle Travel

In 2017, fuel consumption by the transportation sector was dominated by gasoline (66 percent), followed by diesel (22 percent) and jet fuel (11 percent). Under the modeled decarbonization scenarios, gasoline and diesel fuel usage in the transportation sector are replaced primarily by electricity (**Figure 5**). Because electric vehicle motors are more efficient than conventional motors,[60] total fuel consumption declines even as total vehicle miles traveled increases in the Core scenario. Jet fuel use increases in all of the decarbonization scenarios, however, including in the Low Demand case. Aviation poses an ongoing challenge in terms of emission reductions due to the lack of technological options for replacing jet fuel.

As shown in **Figure 6,** passenger vehicle and truck miles decrease significantly in the Low Demand scenario compared to projected travel in the Reference and Core scenarios. The Low Demand scenario can be achieved through a combination of city planning and public transit efforts, and if strategically designed with energy equity considerations in mind, can improve transportation options for low-income households while reducing total pollutant emissions. This scenario maximizes public health co-benefits by replacing automobile trips with active transit such as walking and cycling, which are associated with myriad health and economic benefits,[61,62] alongside public transit expansion.

58 While non-road mobile sources include construction equipment and other mobile sources serving the industrial sector, we include these sources in the transportation sector in this report, as they likely require similar technical and policy solutions to on-road vehicles in terms of vehicle electrification and electric vehicle charging infrastructure.

59 US Energy Information Administration. "Nevada: State Profile and Energy Estimates" (2020). Accessed: Nov. 2020. Available at: https://www.eia.gov/state/analysis.php?sid=NV.

60 US Department of Energy. "All-Electric Vehicles." Accessed: Nov. 2020. Available at: https://www.fueleconomy.gov/feg/evtech.shtml.

61 US Department of Transportation. "Integrate Health and Transportation Planning." Accessed: Nov. 2020. Available at: https://www.transportation.gov/mission/health/Integrate-Health-and-Transportation-Planning.

62 Giles-Corti, Billie, *et al*. The Co-Benefits for Health of Investing in Active Transportation. *New South Wales Public Health Bulletin* 21.6 (2010): 122-127.

FIGURE 5. Fuel consumption by fuel type, across all transportation subsectors, including aviation, passenger and freight rail, and on-road vehicles. Fuel consumption by the transportation sector in 2017 is dominated by gasoline, followed by diesel and jet fuel. The dip in fuel use in the Reference scenario is due to increased fuel efficiency and low levels of electric vehicle adoption, followed by an overall increase in travel and associated fuel demand. Because electricity is more energy efficient than fossil fuels, total energy consumption declines even as total vehicle miles traveled increases in the Core scenario.

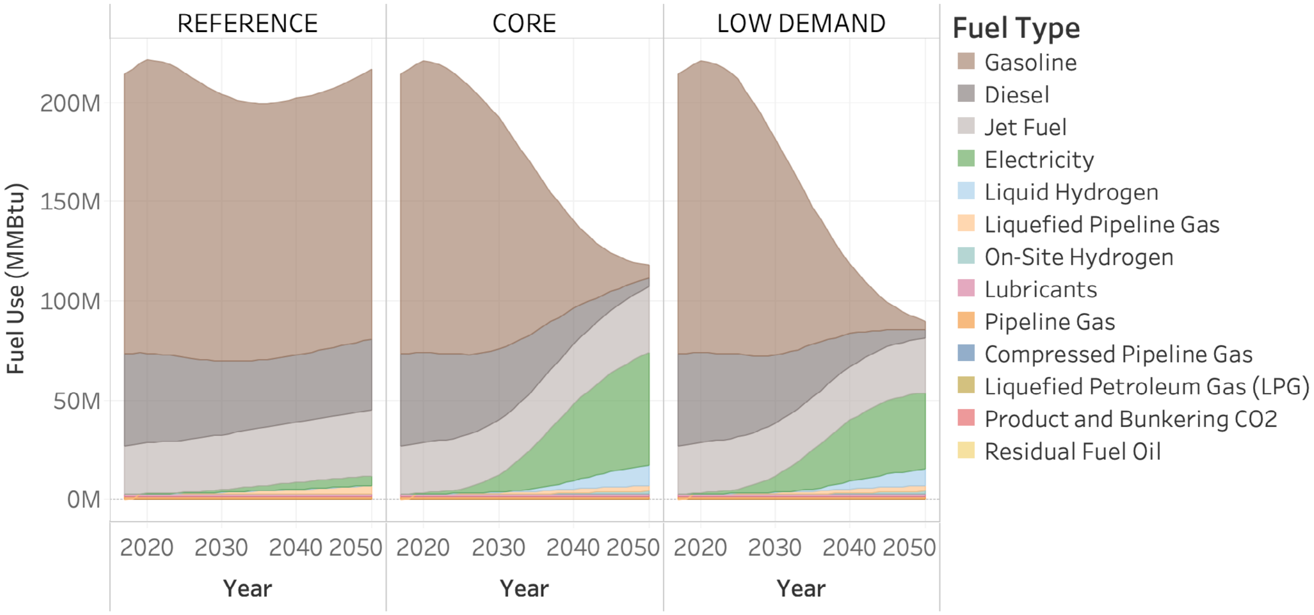
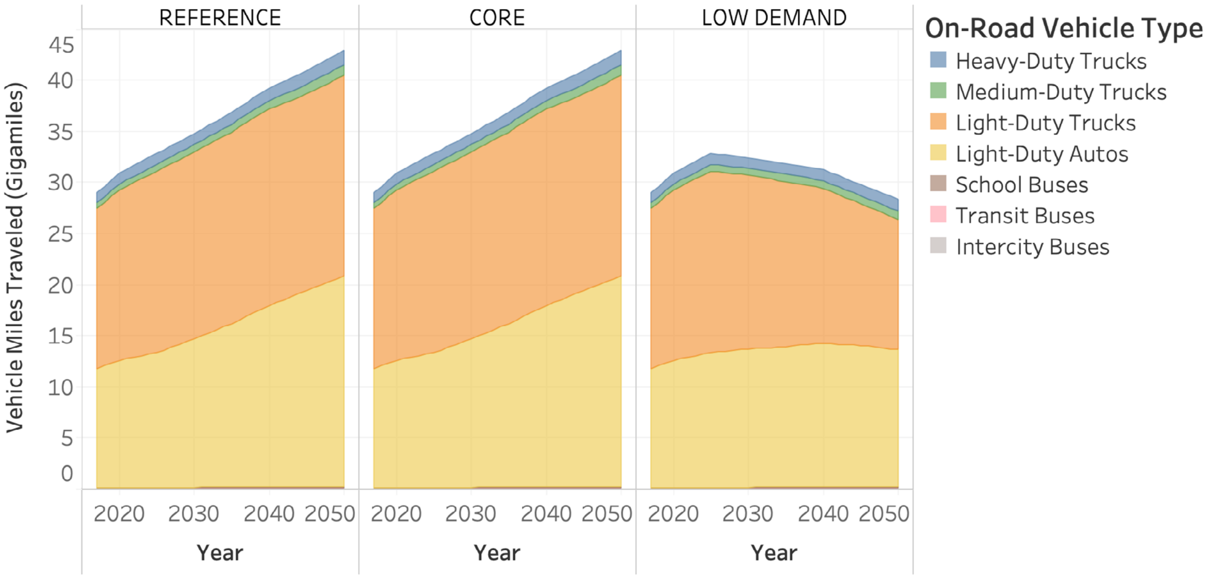
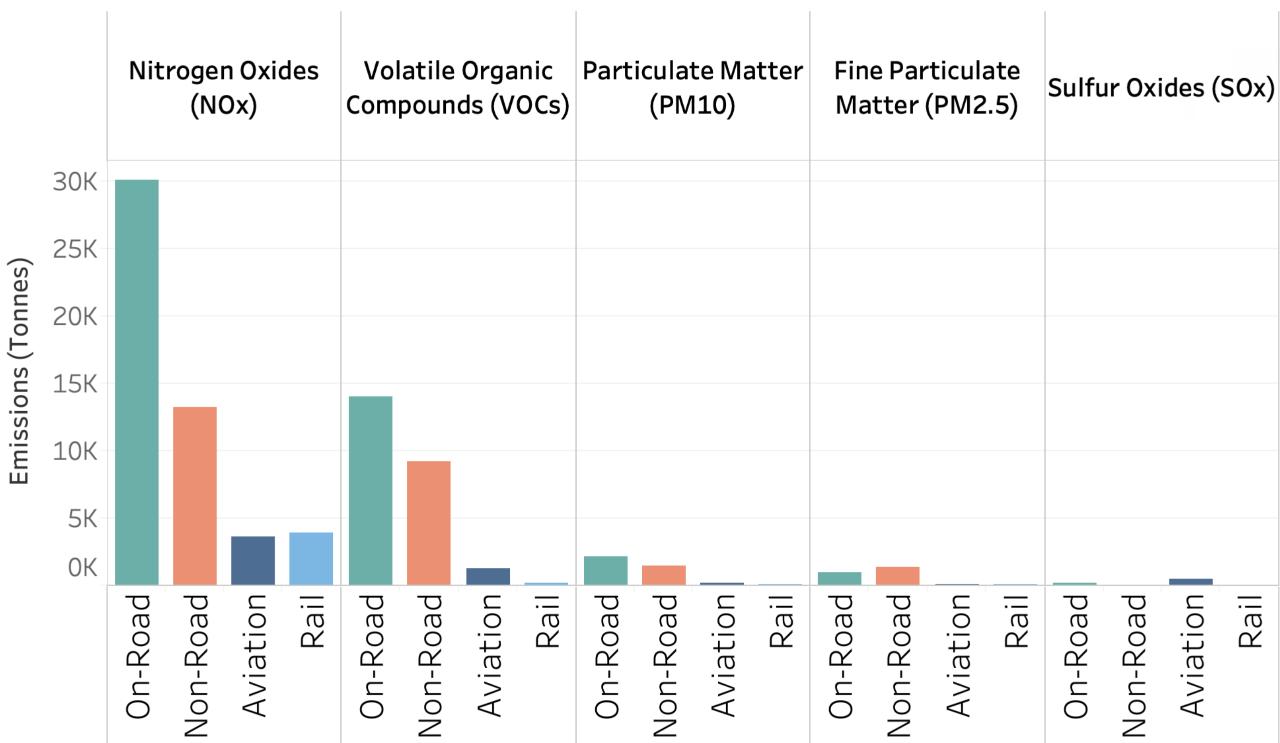


FIGURE 6. Vehicle miles traveled by on-road vehicle type in Nevada. Vehicle miles traveled in light-duty passenger cars and light-duty trucks, which dominate total on-road vehicle miles traveled, grow in the Reference and Core scenarios, as well as the Slow Coal Retirement and Fossil Free scenarios. Only the Low Demand scenario reduces vehicle travel compared to the Reference case.



While on-road vehicle travel declines in the Low Demand scenario, airline, freight rail, and passenger rail travel increase, just as they do in the other decarbonization scenarios. As airports emit significant amounts of health-damaging criteria air pollutants, the projected increase in airline travel in all decarbonization scenarios could exacerbate emissions burdens for communities living in close proximity to Nevada airports. According to the 2017 National Emissions Inventory, Las Vegas McCarran International Airport, which is the eighth largest airport in the country,[63] is Nevada's highest emitting point source of NO_x, VOCs, SO_2, and health-damaging hazardous air pollutants. Neighboring census tracts are majority low-income and people of color, and are among the most linguistically isolated census tracts in the state (top 20 percent). Lingering ground-level emissions from continued use of jet fuel at airports could exacerbate socioeconomic and demographic disparities in emissions burdens even as the rest of the transportation sector decarbonizes.

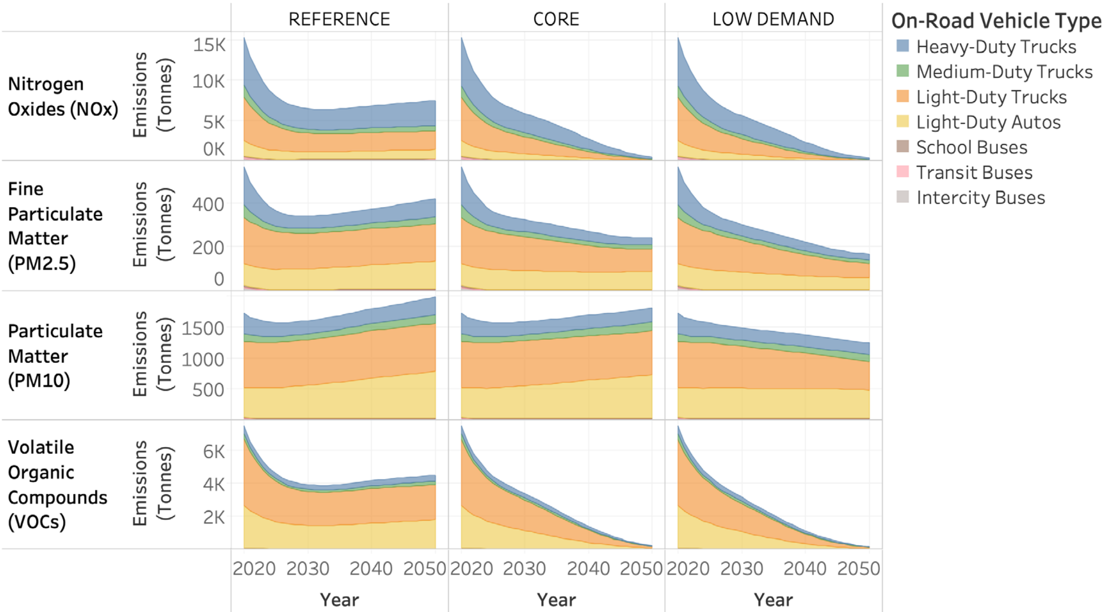
FIGURE 7. 2017 transportation sector criteria air pollutant emissions in Nevada.[64] NO_x dominates total criteria air pollutant emissions from the transportation sector. On-road vehicles contribute the largest share of transportation-related ground-level NO_x, PM_{10}, and VOC emissions, while airports dominate SO_x emissions and non-road mobile sources emit the most $PM_{2.5}$.



63 Center for Business and Economic Research, Lee Business School, UNLV. "Airports." Accessed: Nov. 2020. Available at: https://cber.unlv.edu/SNBDI/airports.html#:~:text=McCarran%20International%20Airport,-McCarran%20International%20Airport&text=There%20are%20more%20than%203%2C400,airport%20in%20the%20United%20States.

64 Aviation, non-road, and rail emissions are from the 2017 National Emissions Inventory (NEI). On-road vehicle emission estimates are from our own analysis, verified against the 2017 NEI (see **Technical Appendix: Methods**).

FIGURE 8. On-road vehicle transportation emissions by decarbonization scenario, 2020-2050. Although light-duty passenger vehicles and light-duty trucks dominate $PM_{2.5}$, PM_{10}, and VOC emissions, heavy-duty trucks contribute a disproportionate share of $PM_{2.5}$, PM_{10}, and NO_x emissions relative to their fraction of total vehicle miles traveled.



2.2.3 Statewide Baseline and Projected Emissions

As shown in **Figure 7,** on-road mobile sources, including light-duty vehicles, buses, and medium-duty and heavy-duty trucks, contribute the largest share of transportation-related ground-level NO_x, PM_{10}, and VOC emissions in Nevada. Non-road sources span the transportation and industrial sectors, including off-road recreational vehicles, construction equipment, lawn and garden equipment, and industrial and mining equipment. These sources dominate fine particulate matter ($PM_{2.5}$) emissions, largely due to exhaust emissions, and are a significant source of PM_{10}, largely due to tire and brake wear and the resuspension of road dust.[65] The aviation sector, which accounts for flight take-off and landing emissions and airport ground support operations, but excludes in-flight emissions, emits the largest share of transportation-related SO_x emissions. Criteria air pollutant emissions from rail are are significantly lower than from other sources.

In the subsequent analysis, we focus primarily on on-road mobile sources due to their large share of transportation-related criteria air pollutant emissions and the availability of spatially granular data for these sources. We estimate on-road vehicle emissions by combining highway vehicle counts with emission factors based on vehicle type and fuel (see **Technical Appendix: Methods**). We find that while light-duty vehicles, including passenger cars and light-duty trucks, make up the vast majority of on-road vehicle miles traveled (as shown in **Figure 6**), heavy-duty trucks contribute disproportionately to NO_x and particulate matter emissions due to their higher emission rates of these pollutants.[66] The modeled total criteria air pollutant emissions by vehicle type from 2020-2050,[67] shown in **Figure 8,** shows both the high share of emissions from light-duty trucks and passenger cars across pollutants, as well as the disproportionate contribution of heavy-duty trucks to $PM_{2.5}$, PM_{10}, and NO_x emissions relative to their share of total vehicle miles traveled.

65 Gertler A.W., Gillies J.A., Pierson W.R. An Assessment of the Mobile Source Contribution to PM_{10} and $PM_{2.5}$ in the United States (2000). In: Belkin S. (eds) Environmental Challenges. Springer, Dordrecht.

66 Throughout our analysis, "medium-duty trucks" refer to single-unit trucks and "heavy-duty trucks" refer to combination-unit trucks.

67 Modeled emissions in the year 2020 do not reflect the impacts of COVID-19 on travel patterns and associated changes in fossil fuel use within the transportation sector.

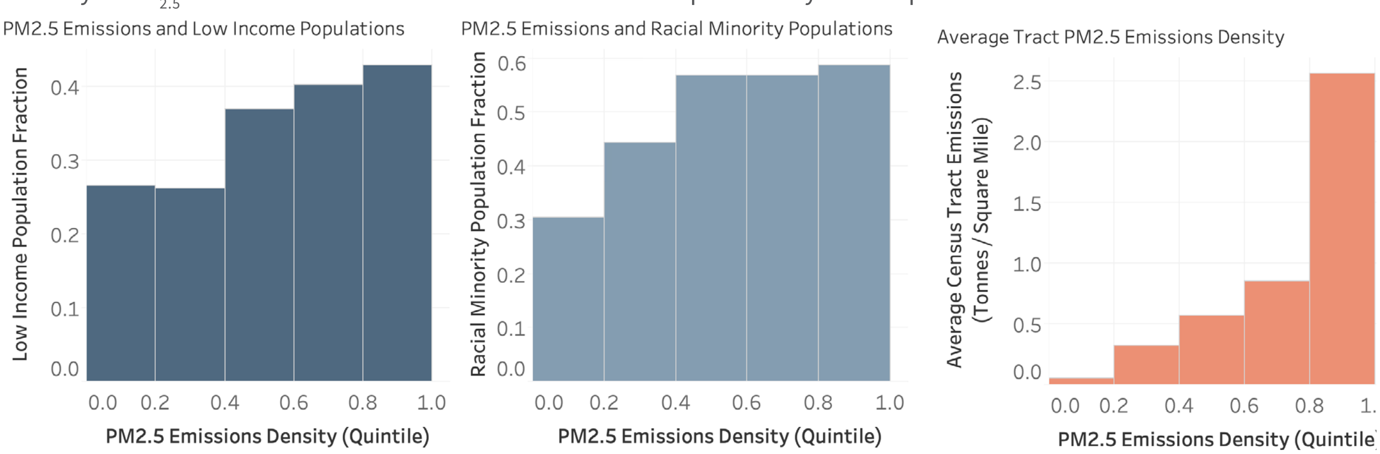
2.2.4 Baseline Emissions: Demographic Analysis

Rural and urban areas differ significantly in terms of transportation characteristics and associated criteria air pollutant emissions. Heavy-duty trucks make up a greater fraction of total vehicle miles traveled in rural areas and along urban interstates, while light-duty vehicles make up a greater fraction of vehicle miles traveled in most urban areas. Because heavy-duty and light-duty vehicles are not distributed evenly across road segments, the amount and composition of primary pollutant emissions from on-road vehicles vary throughout the state.

While the distribution of primary pollutant emissions can provide an initial screening of areas with particularly high levels of local emissions, it is important to note that primary pollutant emissions do not necessarily correspond to local air pollutant concentrations. Secondary pollutants such as ozone can form downwind of emissions sources, contributing to health-damaging air pollution in regions of the state far from the initial source of primary pollutants. As modeling the formation of secondary pollutants was outside the scope of our analysis, we used the spatial distribution of primary $PM_{2.5}$ emissions—which have a well-documented association with local adverse health impacts[68]—as a proxy to represent local risk of exposure to air pollution from on-road mobile sources. Additionally, as census tracts serve as our spatial unit of analysis for demographic data, we normalize emissions estimates by census tract land area (tonnes emitted per square mile) in order to compare air pollution exposure risk between populations living in census tracts of varying size. We refer to area-normalized emission estimates as *emissions density* throughout this report, using this metric as a proxy for exposure risk to air pollution in our analysis of transportation and cross-sectoral emissions.

Statewide, census tracts with higher proportions of people of color and low-income households tend to have higher emissions densities across all criteria air pollutants, as shown in **Figure 9** for $PM_{2.5}$. Because we used statewide average emissions factors to estimate tract-level emissions from on-road vehicles, our methodology may even underestimate emissions in lower-income census tracts, where households tend to drive older vehicles with higher criteria air pollutant emission factors (assuming local residents comprise a meaningful proportion of vehicle miles traveled within any given tract).[69]

FIGURE 9. 2017 $PM_{2.5}$ emissions from on-road vehicles and demographics of nearby populations. A higher fraction of the population are people of color and low-income in census tracts with higher $PM_{2.5}$ emissions densities. Census tracts are grouped into quintiles based on their $PM_{2.5}$ emissions density (tonnes / square mile) from on-road vehicles. The top two figures show the fraction of the population across census tracts in each quintile that is low-income (left) and people of color (right). The bottom figure shows $PM_{2.5}$ emissions density for the average census tract in each quintile. The density of $PM_{2.5}$ emissions from on-road vehicles increases exponentially across quintile brackets.



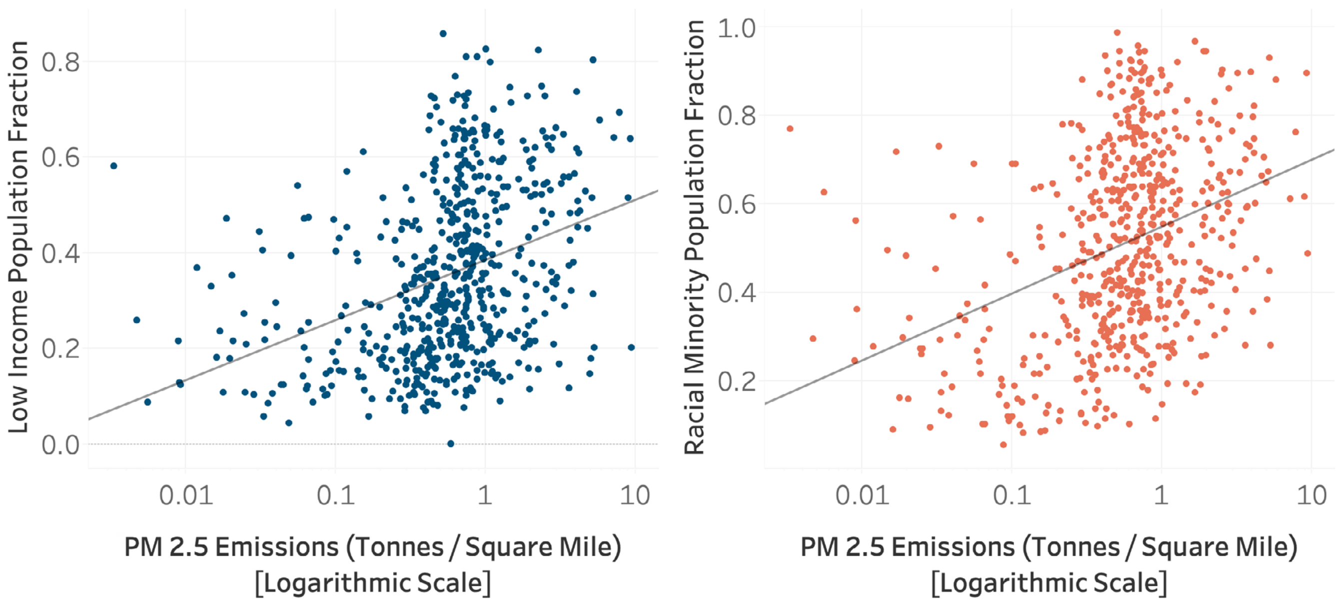
68 Loomis, Dana *et. al*. IARC Evaluation of the Carcinogenicity of Outdoor Air Pollution. *The Lancet Oncology* 14 (2013):1262–1263.

69 US Energy Information Administration. “U.S. Households Are Holding on to Their Vehicles Longer.” Dec. 2018. Available at: https://www.eia.gov/todayinenergy/detail.php?id=36914.

While traffic emissions are more highly concentrated in urban areas, where people of color make up a greater fraction of the population, we still see a racial disparity in exposure risk to near-roadway air pollution when controlling for this confounding variable. If we exclude rural areas,[70] analyzing the distribution of emissions solely within metropolitan areas, we still see a positive trend between low income and racial minority population fraction and emissions density, as shown in **Figure 10**.

Within rural areas, we did not find a statistically significant correlation between low-income population fraction and $PM_{2.5}$ emissions density or racial minority population fraction and $PM_{2.5}$ emissions density.

FIGURE 10. 2017 $PM_{2.5}$ emissions density (tonnes / square mile) from on-road vehicles and demographic indicators in metropolitan areas. Each dot represents a census tract within a US Census Bureau-defined metropolitan statistical area in Nevada, in aggregate representing roughly 90 percent of the statewide population. The positive correlation between $PM_{2.5}$ emissions density from on-road vehicles and low-income (left) and racial minority (right) populations in metropolitan areas is statistically significant (p-value < 0.01).



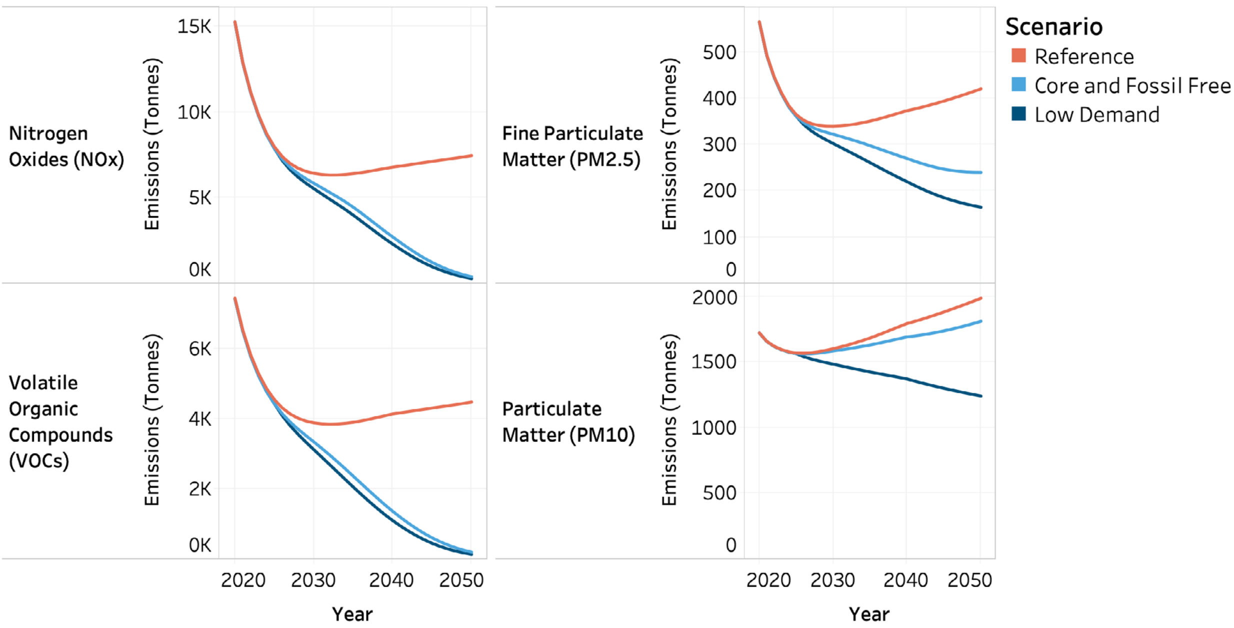
70 Rural areas refer to all census tracts that are not designated as metropolitan statistical areas by the US Census Bureau. This includes micropolitan statistical areas (at least one urban cluster of at least 10,000 but less than 50,000 population), as well as census tracts that are neither metropolitan or micropolitan.

2.2.5 Projected Emissions: Demographic Analysis

Electrification of on-road vehicles in each of the decarbonization scenarios reduces criteria air pollutant emissions significantly compared to the Reference case, although these impacts are largely seen after 2030 (**Figure 11**). From 2020-2025, the sharp decline in criteria air pollutant emissions in both the Reference and decarbonization scenarios is largely driven by the retirement of old, high-emitting vehicles with outdated pollution control technologies (**Figure 11**).

While NO_x and VOC emissions reach near-zero emissions by 2050 in all four decarbonization scenarios, a significant portion of $PM_{2.5}$ emissions remain, and PM_{10} emissions are only reduced in the Low Demand scenario (**Figure 11**). Electric vehicles still contribute non-exhaust $PM_{2.5}$ and PM_{10} emissions through tire and brake wear, which are reflected in the emission factors we used to estimate emissions from alternative fuel vehicles (**Figure 12**).[71,72] While electric vehicles use regenerative braking, which may reduce particulate matter emissions from brake wear, they are also heavier than conventional vehicles on average, which may increase particulate matter emissions from tire wear.[73] Conventional and alternative fuel vehicles also produce PM_{10} emissions through the resuspension of dust and other particulate matter on road surfaces, although these non-exhaust emissions are not reflected in our emission estimates.

FIGURE 11. Air pollutant emission reductions by scenario, 2020-2050.[74] Unlike the other pollutants, PM_{10} emissions do not decrease substantially from 2020-2050 in the Core, Fossil Free, and Slow Coal Retirement scenarios due to an increase in total vehicle miles traveled and a corresponding increase in emissions from tire and brake wear. The Low Demand scenario achieves the greatest $PM_{2.5}$ and PM_{10} emission reductions, underscoring the public health benefits of reduced vehicle travel.



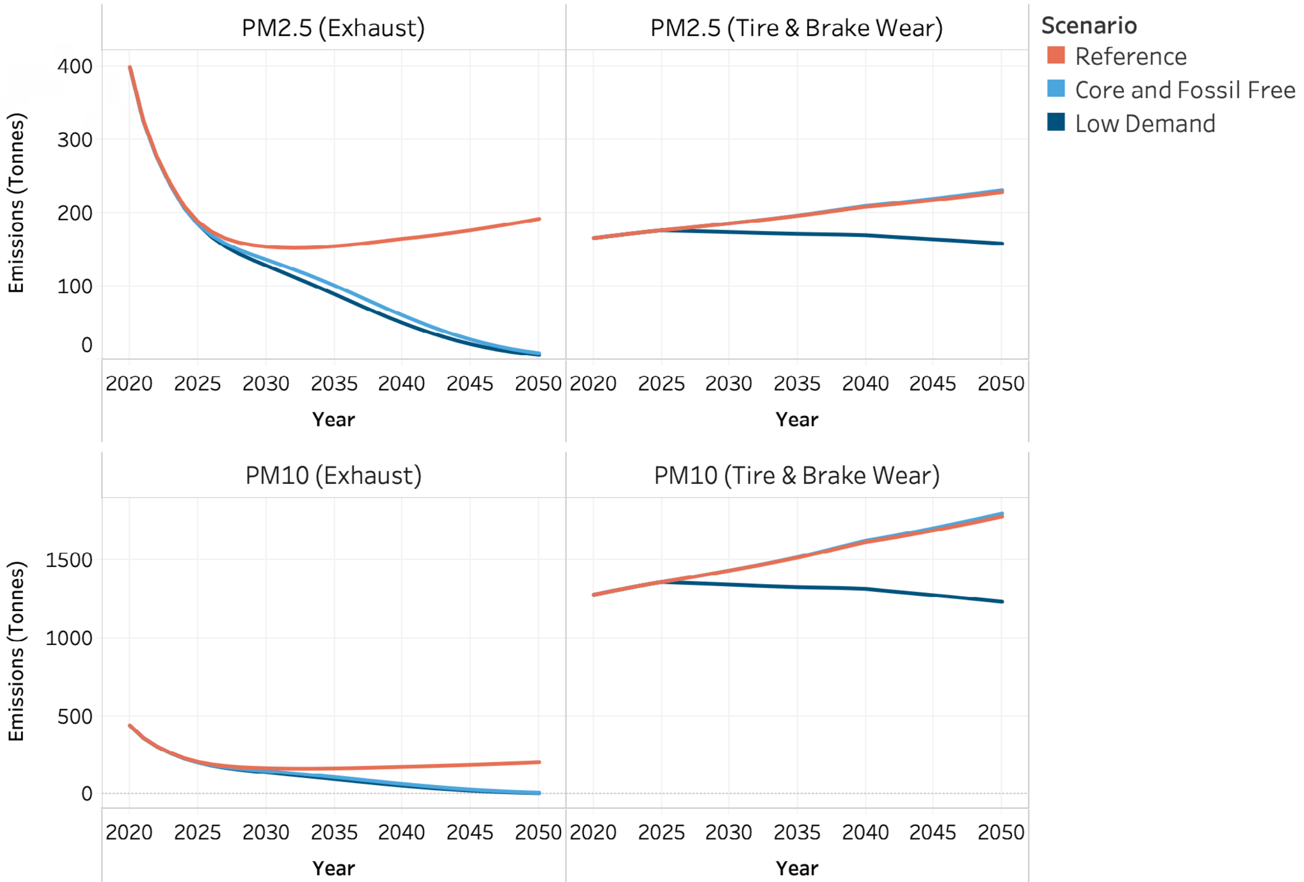
71 Working Party on Integrating Environmental and Economic Policies, Organisation for Economic Co-operation and Development (OECD). Non-Exhaust Emissions from Road Transport: Causes, Consequences and Policy Responses (2020).

72 Argonne National Laboratory. "Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool" (2019). Accessed: July 2020. Available at: https://greet.es.anl.gov/afleet.

73 Beddows, David C.S. and Roy M. Harrison. PM_{10} and $PM_{2.5}$ Emission Factors for Non-Exhaust Particles from Road Vehicles: Dependence upon Vehicle Mass and Implications for Battery Electric Vehicles. *Atmospheric Environment, 244: 117886* (2021).

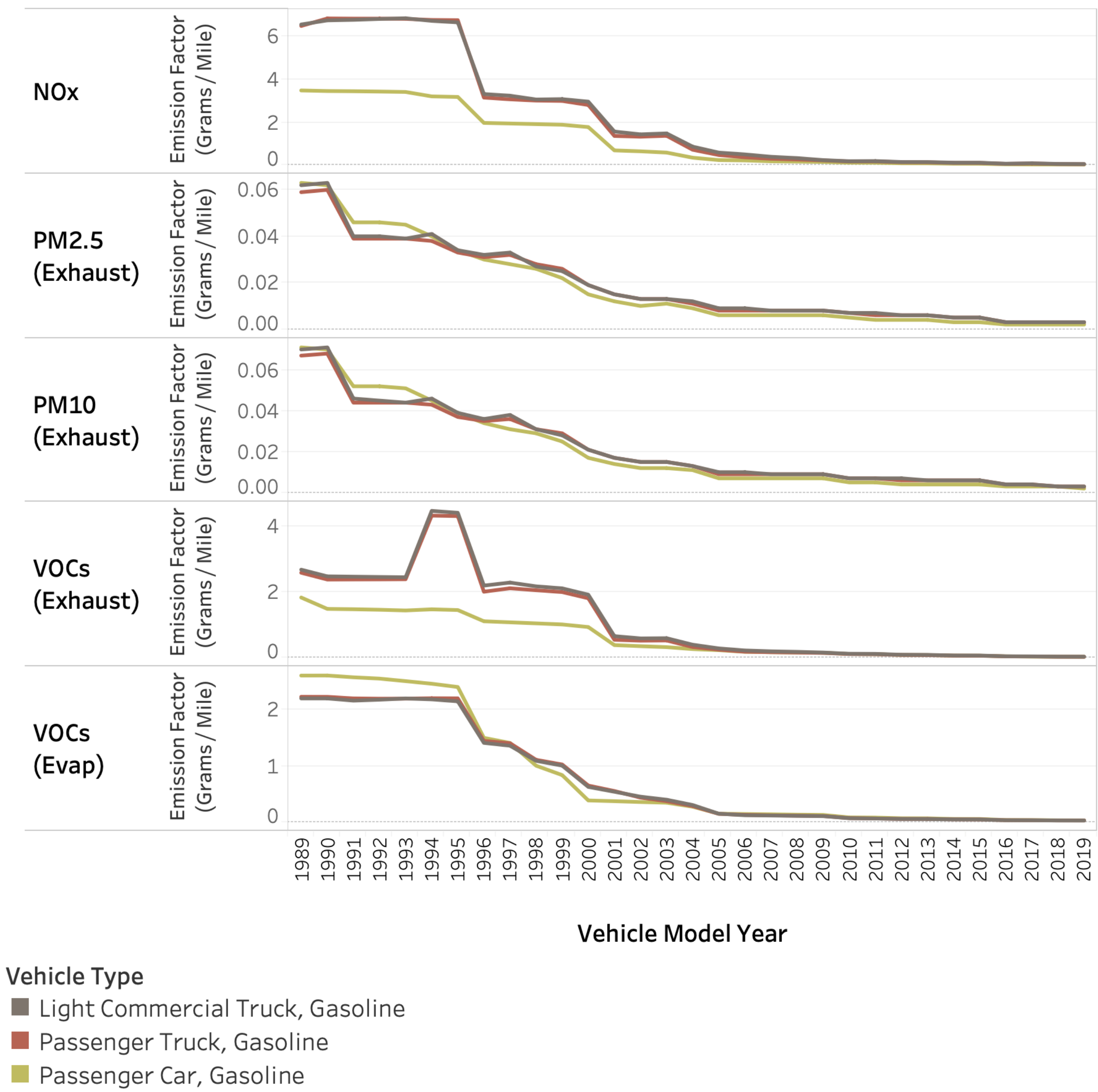
74 Projected emission estimates are based on Evolved Energy's assumed allocation of vehicle miles traveled by vehicle vintage in each analysis year. Our transportation baseline year (2017) emission estimates throughout the report are based on EPA MOVES' default vehicle age distribution, and are verified against the National Emissions Inventory (NEI) 2017 emission estimates. Due to discrepancies in the assumed vehicle age distribution utilized by these two methods, they result in different baseline emission estimates for the transportation sector across pollutants. This underscores the need for better state-specific data on the vehicle age distribution and allocation of vehicle miles traveled by vintage for each vehicle type.

FIGURE 12. $PM_{2.5}$ and PM_{10} exhaust and non-exhaust emissions by scenario, 2020-2050. While all decarbonization scenarios eliminate exhaust emissions of $PM_{2.5}$ and PM_{10}, only the Low Demand scenario reduces non-exhaust emissions of $PM_{2.5}$ and PM_{10} by 2050. Because vehicle PM_{10} emissions are largely due to tire and brake wear rather than exhaust, increased vehicle travel across scenarios from 2020-2050 results in an increase in overall PM_{10} emissions in the Reference case, and no substantial reduction in PM_{10} emissions in the Core and Fossil Free scenarios.



Projected on-road vehicle emissions are highly dependent on the assumed vehicle age distribution underlying the fleet of each vehicle type. Across pollutants, older vehicles have higher emission factors (grams emitted per mile) than newer vehicles because of the different technological and regulatory constraints in place at the time they were manufactured (**Figure 13**). The modeled rate of vehicle turnover in each year of the decarbonization analysis as well as the assumed allocation of vehicle miles traveled by vehicle vintage therefore heavily impact the rate of emission reductions achieved throughout the decarbonization timeline. **Figure 14** illustrates the sensitivity of our modeled emission projections to underlying vehicle age distribution assumptions, and highlights the impact that prioritized retirement of older vehicles has on total emissions. The retirement of older heavy-duty and medium-duty trucks has a particularly significant impact on near-term $PM_{2.5}$ and NO_x emission reductions, as emission factors for these vehicle types have declined substantially over the past several decades (**Figure 13**).

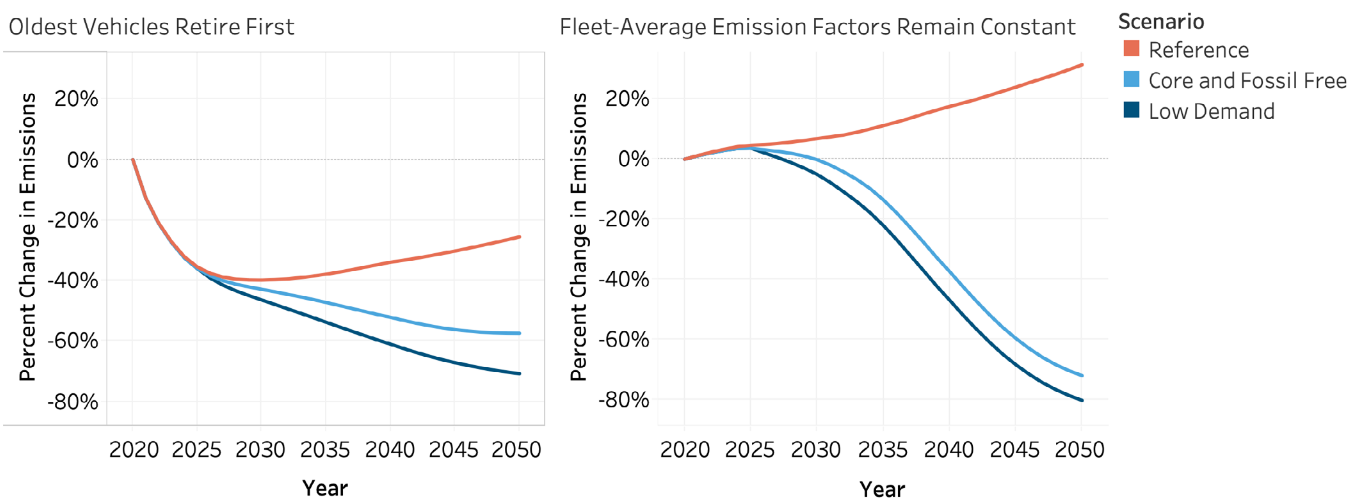
FIGURE 13. a) Nevada heavy-duty and medium-duty diesel vehicle emission factors by model year and b) Nevada light-duty gasoline vehicle emission factors by model year.[75] The substantial decline in vehicle emission factors (grams of pollutant emitted per mile) over the last several decades underscores the need to retire older vehicles first in order to achieve maximal emission reductions in the coming decade. The sharp reduction in heavy-duty and medium-duty vehicle $PM_{2.5}$ and PM_{10} emission factors from model year 2006 to model year 2007 reflects the adoption of an EPA rulemaking in 2001 (66 FR 5002, January 18, 2001) requiring all on-road diesel heavy-duty vehicles, starting with the 2007 model year, to use a diesel particulate filter.[76] The rulemaking also required a phased-in adoption of NO_x exhaust control technology from 2007-2010.



75 We accessed EPA MOVES 2014a emission factors through the Argonne National Laboratory's 2019 AFLEET tool. We are unaware of an explanation for the dip in EPA MOVES emission factors from 1990-1994 for several vehicle types.

76 Manufacturers of Emission Controls Association (MECA). "U.S. EPA 2007/2010 Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements." Accessed: Nov. 2020. Available at: http://www.meca.org/regulation/us-epa-20072010-heavyduty-engine-and-vehicle-standards-and-highway-diesel-fuel-sulfur-control-requirements.

FIGURE 14. Projected on-road $PM_{2.5}$ emissions: sensitivity to assumed vehicle age distribution. Because older vehicles have higher emission factors, projected on-road vehicle emissions are highly sensitive to the assumed vehicle age distribution for each vehicle type. In the left figure, we assume that the oldest internal combustion engine vehicles are continually replaced by newer, less-polluting internal combustion engine vehicles throughout decarbonization. In the right figure, we assume that fleet-average emission factors for internal combustion engine vehicles remain constant over time,[77] modeling only the emission reductions achieved through fuel switching and vehicle electrification. The discrepancy between these two results emphasizes the significant impact that retiring old vehicles, particularly trucks, has on emission reductions.



Criteria air pollutant emission reductions do not occur uniformly across the state. Because heavy-duty and light-duty vehicles make up different proportions of total vehicle miles traveled in different parts of the state, and each vehicle class reduces pollution at a different rate, certain regions see more aggressive emission reductions than others throughout the decarbonization timeline. Different assumptions about the underlying vehicle age distribution, as discussed above, affect where emission reductions are greatest in the near-term.

If we assume that fleet-average emission factors remain constant over time for conventional fuel vehicles, census tracts in close proximity to trucking routes lag behind other areas in reducing emissions from 2020-2030 in the Core scenario (**Figure 15,** top panel). Some census tracts in rural areas and along urban interstate corridors, where heavy-duty and medium-duty trucks make up a greater fraction of vehicle miles traveled, even see an increase in emissions over the next decade. This is because heavy-duty and medium-duty trucks electrify more slowly than light-duty vehicles, while still seeing an increase in vehicle miles traveled over this period. If we assume that fleet-average emission factors change over time due to the retirement of old, high-emitting conventional fuel vehicles, however, census tracts in close proximity to trucking routes see more aggressive emission reductions than other areas from 2020-2030 in the Core scenario (**Figure 15**, bottom panel). Retiring old heavy-duty and medium-duty trucks has an outsized impact on emission reductions, because these vehicle types have seen particularly sharp declines in PM_{10}, $PM_{2.5}$, and NO_x emission factors over the last several decades.

The two different emission reduction trajectories depicted in **Figure 15** suggest that whether or not the retirement of old, high-emitting vehicles is prioritized has implications for environmental equity outcomes.

77 Fleet-average emission factors are calculated by weighting emission factors for each model year using the EPA MOVES 2014a default vehicle age distribution for each vehicle type in analysis year 2019.

Many of the census tracts adjacent to urban interstates in the Las Vegas metro area have high scores on the Demographic Index, primarily due to their high population fractions of people of color and low-income households (**Figure 16**). If old, high-emitting heavy-duty and medium-duty trucks remain on the road, these census tracts could see slower rates of PM_{10}, $PM_{2.5}$ and NO_x emission reductions compared to other areas in the coming decade. Incentivizing the retirement of these highly-polluting older vehicles, by contrast, could help to achieve greater emission reductions in these areas in the near-term.

FIGURE 15. Modeled percent change in on-road vehicle $PM_{2.5}$ emissions by census tract from 2020-2030 in the Core scenario under different vehicle age distribution assumptions. Under the assumption that fleet-average emission factors for internal combustion engine vehicles remain constant over time, the Core scenario results in an increase in $PM_{2.5}$ emissions along trucking routes from 2020-2030 due to increased vehicle travel and associated emissions (top). Under the assumption that, in addition to vehicle electrification, the oldest internal combustion engine vehicles are continually replaced by newer, less-polluting internal combustion engines throughout decarbonization, the Core scenario results in emission reductions everywhere in the state by 2030, with more aggressive emission reductions along trucking routes (bottom). The contrast between these two trajectories emphasizes the significant impact that retiring old trucks has on emission reductions and environmental equity outcomes.

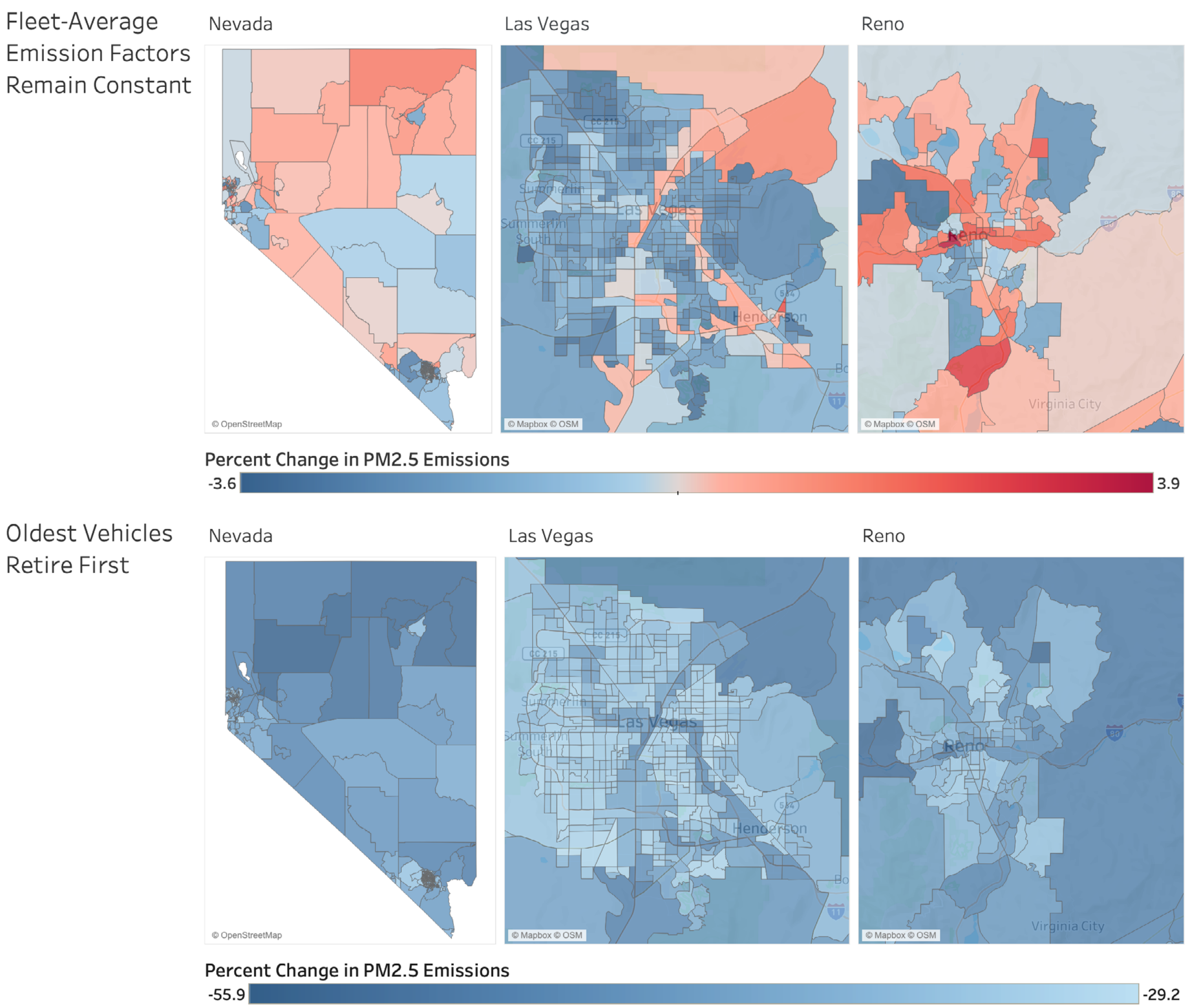
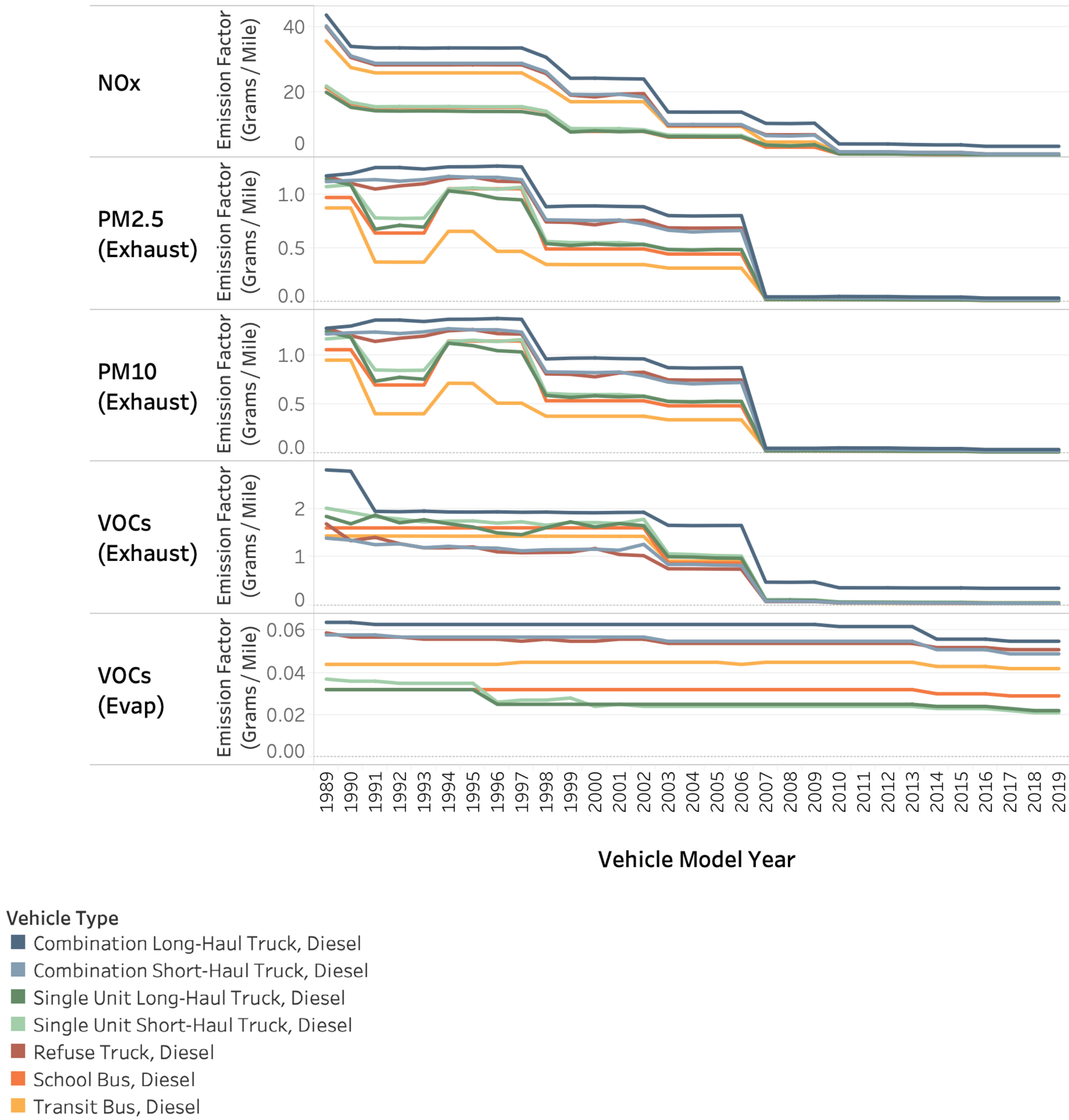


FIGURE 16. On-road vehicle $PM_{2.5}$ emissions in 2020 in the Core Scenario (left), residual $PM_{2.5}$ emissions in 2050 (middle), and Demographic Index percentile in the Las Vegas metropolitan region (right). $PM_{2.5}$ emissions are most concentrated in census tracts along urban interstate and highway corridors, and remain in these areas in 2050 due to continued emissions from vehicle tire and brake wear. Many of the census tracts adjacent to urban interstates and highways in the Las Vegas metro area have high scores on the Demographic Index.

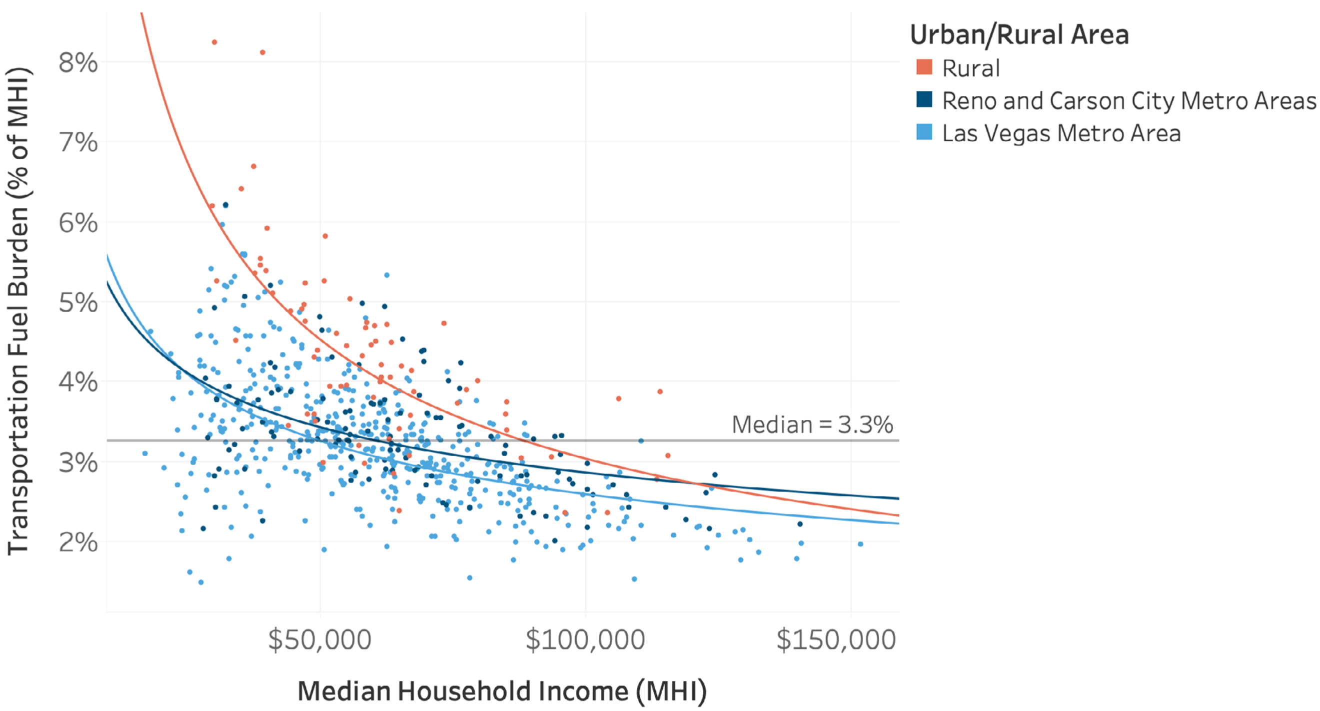


Incorporating measures from the Low Demand scenario, such as investment in public transit and the reduction of vehicle travel, could help to mitigate the environmental equity issues associated with residual $PM_{2.5}$ and PM_{10} emissions along urban interstate and highway corridors in the Core scenario. In addition, prioritizing electric vehicle charging infrastructure along urban interstate and highway corridors, rerouting heavy-duty and medium-duty trucks to less populated areas, addressing bus and truck idling in urban and industrial areas, and electrifying trucks and non-road vehicles associated with industrial activity in dense urban areas could help to address the inequitable emissions burden faced by urban low-income communities and communities of color.

2.2.6 Vehicle Fuel Cost Burdens

In addition to the disproportionate traffic density and associated emissions occurring in low-income communities and communities of color, these households often have high vehicle fuel cost burdens. Although higher income households drive more than lower-income households on average, lower-income households tend to spend a greater fraction of their income on vehicle fuel (**Figure 17**). Importantly, our vehicle fuel cost burden estimates do not include public transit costs or the costs of vehicle ownership and maintenance, the latter of which are far higher than annual vehicle fuel costs on average.[78] The inclusion of these costs in our estimates would result in much higher average transportation cost burdens for households across income levels.

FIGURE 17. a) Average annual household vehicle miles traveled and b) average vehicle fuel cost burden by census tract median household income. Lower-income households drive less than higher-income households on average, but spend a greater fraction of their annual income on vehicle fuel. Rural households have higher vehicle fuel cost burdens than urban households on average, in part due to longer average driving distances and lower average household incomes.

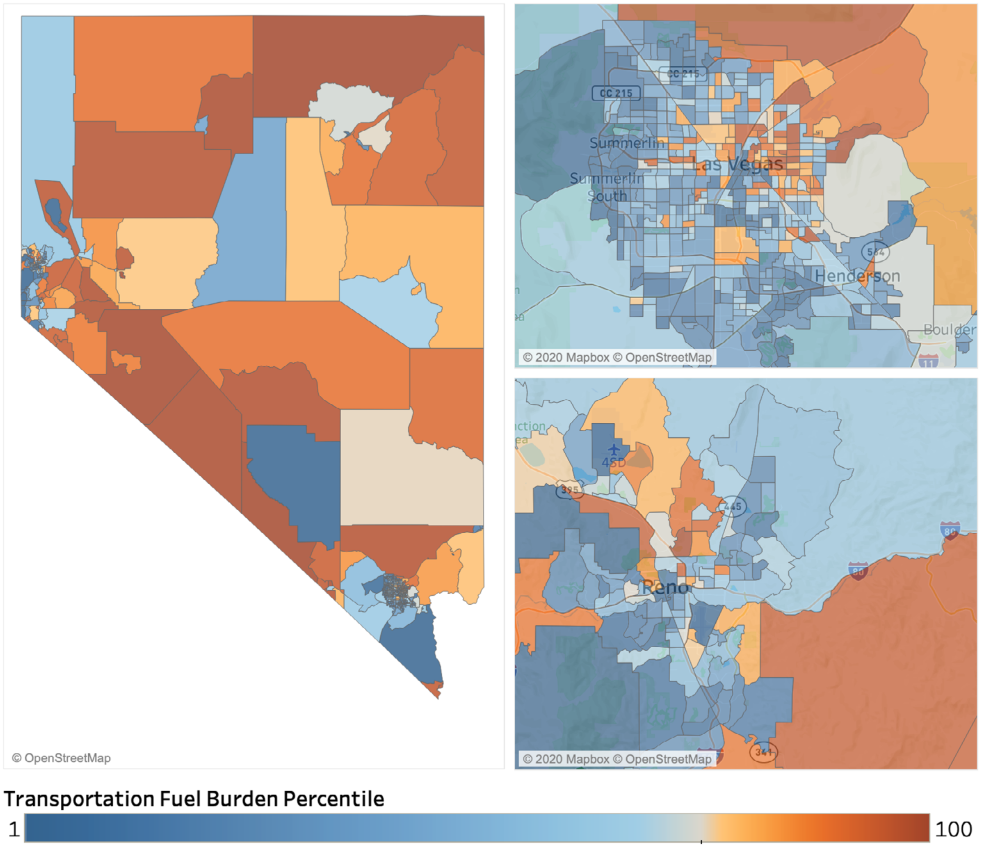


78 Center for Neighborhood Technology. "Housing and Transportation (H+T®) Affordability Index." Accessed: Nov. 2020. Available at: https://htaindex.cnt.org/.

For reference, the Center for Neighborhood Technology (CNT) estimates that a *Regional Typical Household*[79] in the Las Vegas metropolitan region spends roughly 24 percent of their annual income on transportation costs, when accounting for vehicle ownership and maintenance costs, fuel costs, and public transit costs.[80] By analyzing only the transportation cost burden imposed on households by vehicle fuel costs, our findings are limited in scope. Still, our conclusions point to an equity consideration relevant to the reduction of carbon emissions from household travel. Because higher-income households drive more and consume more fuel on average,[81] and therefore likely contribute more to transportation-related carbon emissions, policies designed solely to reduce carbon emissions from household vehicle travel may fail to address the transportation-related financial burden faced by low-income households.

Vehicle fuel cost burdens are higher on average in rural areas of Nevada, in part due to longer average driving distances and lower average incomes compared to urban areas. In certain areas of Las Vegas and Reno, however, particularly census tracts that are majority people of color and low-income, vehicle fuel cost burdens are higher than 75 percent of census tracts statewide (**Figure 18**). These areas may benefit from programs targeted at low-income households such as free, electrified public transit, financing for electric vehicles, and investment in public electric vehicle charging infrastructure.

FIGURE 18: **Transportation fuel burden percentile by census tract statewide and in Las Vegas and Reno.** While rural households have higher vehicle fuel cost burdens than urban households on average, certain areas within the Las Vegas and Reno metropolitan regions have fuel cost burdens higher than 75 percent of census tracts statewide. Expanding free, electrified public transit, subsidizing electric vehicle adoption, and building out public electric vehicle charging infrastructure in these areas may help to reduce financial burdens incurred by household vehicle travel.



79 According to the Center for Neighborhood Technology, a *Regional Typical Household* in the Las Vegas metropolitan area has the following characteristics: Income: $51,575; Commuters: 1.21; Household Size: 2.78.

80 Center for Neighborhood Technology. “Housing and Transportation (H+T®) Affordability Index.” Accessed: Nov. 2020. Available at: https://htaindex.cnt.org/.

81 US Energy Information Administration. “Household Spending on Gasoline and Public Transit Varies by Region, Income,” Apr. 2015. Available at: https://www.eia.gov/todayinenergy/detail.php?id=20772.

2.2.7 Electric Vehicle Adoption

Throughout our analysis, we assume that vehicle electrification occurs uniformly across the state, meaning that the electric vehicle adoption rates vary by vehicle class but not by geographic location. In reality, electric vehicle adoption rates across the country tend to be higher among consumers who are highly educated, have higher incomes, and own single-family homes.[82] As Nevada's transportation sector decarbonizes, low-income households, communities of color, linguistically-isolated households, and households with lower educational attainment risk facing disproportionately low electric vehicle adoption rates in the coming decade, if adoption trends are similar to those we see for residential rooftop solar.[83, 84] These households may be excluded from the financial and emission reduction benefits associated with vehicle electrification in the near-term, unless the cost of electric vehicles declines substantially and policies are implemented to reduce barriers to electric vehicle access.

As lower-income households tend to drive older, more polluting vehicles,[85] vehicle electrification has the potential to achieve higher criteria air pollutant emission reduction benefits per vehicle mile traveled for this population segment. While higher-income households drive more and consume more fuel on average,[86] and likely contribute more to overall CO_2 emissions due to higher vehicle miles traveled, replacing a lower income household's car with an electric vehicle would likely achieve greater criteria air pollutant emission reductions per vehicle mile traveled by replacing an older, more polluting vehicle.

Primary barriers to widespread electric vehicle adoption include but are not limited to up-front cost, vehicle travel range, and access to charging infrastructure.[87] As the cost of electric vehicles declines and vehicle travel range continues to improve, access to public charging infrastructure may become a key localized barrier to electric vehicle adoption over the next decade.[88] Particularly in Nevada, which has a very high fraction of renters (45 percent),[89] public charging infrastructure is critical to facilitating adoption of electric vehicles among residents without access to home chargers. As with energy efficiency improvements, the installation of private residential chargers suffers from the split-incentive problem, in which landlords are not incentivized to pay for home upgrades that primarily save their tenants money.

Based on data from the US Department of Energy's Alternative Fuel Data Center, there are currently about 30 public electric vehicle charging outlets per 100,000 people in Nevada.[90] For comparison, the rate of public charging outlets per 100,000 people in the US ranges from 4.8 in Alaska to 105.3 in Vermont.[91] In the Las Vegas metropolitan region, electric vehicle charging stations are primarily located in areas with low Demographic Index rankings, clustered at shopping malls, casinos, and other large venues surrounding the Arts District and the Las Vegas Strip (**Figure 19**). While these areas have a particularly high fraction of renter-occupied housing, it is unclear the extent to which the existing charging infrastructure serves tourism and commercial activity in these neighborhoods, or whether it is sufficiently accessible to nearby residents.

82 Hsu, Chih-Wei and Kevin Fingerman. Public Electric Vehicle Charger Access Disparities Across Race and Income in California. *Transport Policy* 100 (2021): 59-67.

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

84 Sunter, D.A., *et al.* Disparities in Rooftop Photovoltaics Deployment in the United States by Race and Ethnicity. *Nature Sustainability* 2.1 (2019): 71-76.

85 US Energy Information Administration. "U.S. Households Are Holding on to Their Vehicles Longer," Aug. 2018. Available at: https://www.eia.gov/todayinenergy/detail.php?id=36914.

86 US Energy Information Administration. "Household spending on gasoline and public transit varies by region, income," Apr. 2015. Available at: https://www.eia.gov/todayinenergy/detail.php?id=20772#.

87 Hsu, Chih-Wei and Kevin Fingerman (2021).

88 *Ibid*.

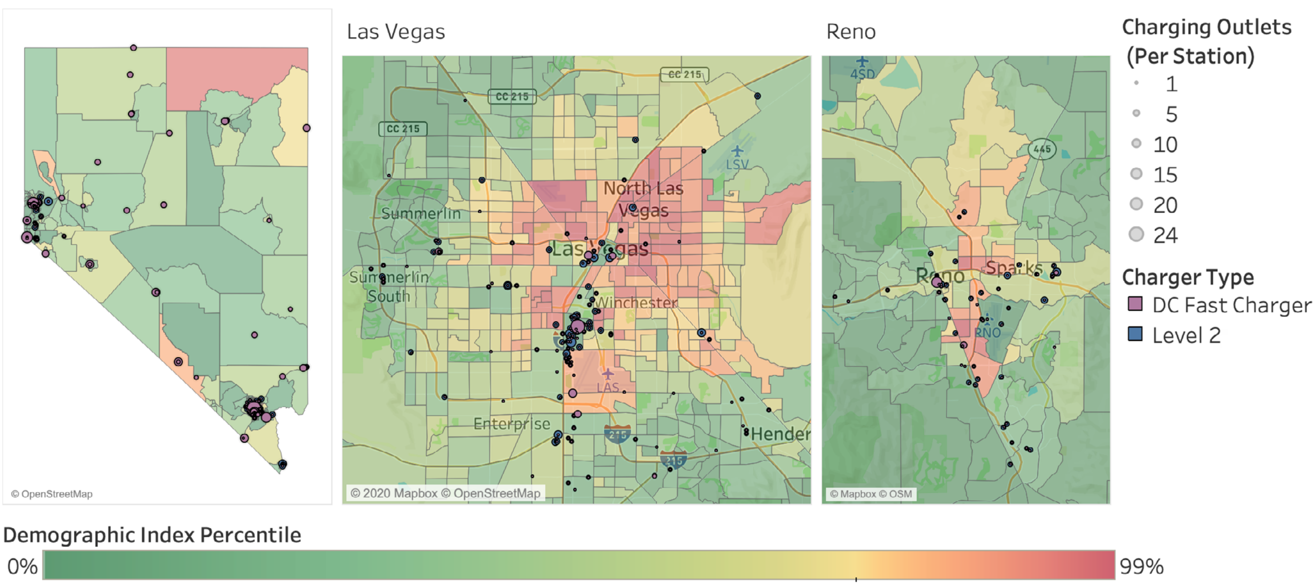
89 US Census Bureau. "Quickfacts: Nevada" (2019). Accessed Nov. 2020. Available at: https://www.census.gov/quickfacts/NV.

90 US Department of Energy Alternative Fuels Data Center. "Alternative Fueling Station Locator." Accessed: Nov. 2020. Available at: https://afdc.energy.gov/stations#/analyze?region=US-NV&country=US&fuel=ELEC&ev_levels=all.

91 Brown, A., *et al.* Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: First Quarter 2020. *National Renewable Energy Laboratory* (2020).

As Nevada continues to expand public charging infrastructure, ensuring that infrastructure is equitably distributed rather than concentrated in areas with high early adoption rates will be critical to facilitating access among households with historically low levels of electric vehicle adoption. Ensuring that public charging infrastructure is accessible to residents in the northern and eastern parts of the Las Vegas metropolitan area in particular, where populations are majority people of color, majority low-income, and have particularly high fractions of linguistically-isolated households, could help the state to reach households who likely face high barriers to electric vehicle adoption. Households in these areas also have particularly high vehicle fuel cost burdens compared to the rest of the state, and would likely benefit from the financial savings associated with electric vehicle adoption (**Figure 18**).

FIGURE 19. Public electric vehicle charging stations and demographic index in Nevada.[92,93] Each dot represents an electric vehicle charging station, while the bubble size reflects the number of charging outlets, known as electric vehicle supply equipment (EVSE), per station. In the Las Vegas metropolitan region, electric vehicle charging stations are primarily located at large venues such as shopping malls and casinos in census tracts with low Demographic Index rankings. Stations are particularly concentrated in commercial neighborhoods near the Arts District and the Las Vegas Strip.



92 US Department of Energy Alternative Fuels Data Center. "Alternative Fueling Station Locator." Accessed: Nov. 2020. Available at: https://afdc.energy.gov/stations#/analyze?region=US-NV&country=US&fuel=ELEC&ev_levels=all

93 The map includes AC Level 2 (240v) and DC fast charging outlets, the latter of which provides electric vehicles with a higher travel range per unit of time charging.

2.3 Residential Buildings

We used a regression model based on geographic, climatic, demographic, and housing-related variables to estimate census tract-level fuel use (see **Technical Appendix: Methods**). Our emissions analysis includes the most commonly combusted residential fuels in Nevada: natural gas, propane, and wood. Our consumer energy utility bill analysis also includes electricity. Electricity generation itself is omitted from the residential sector emissions analysis because these emissions are accounted for in the power sector, but electricity use is included in the cost analysis to get a full picture of household energy bills. A small portion of Nevada households use less common fuels, such as fuel oil. Although these fuels are excluded from this analysis, they should be included when planning residential decarbonization policy.

Residential fuel use across Nevada creates both indoor and outdoor air pollution, and when combined with electricity use can contribute to burdensome utility bills, particularly for low-income households, populations of color, and renters, as we show below. Electrification of natural gas and propane appliances, as well as whole-building efficiency measures, can save energy, reduce bills, and improve indoor air quality. However, these benefits may accrue unevenly and even exacerbate energy cost burdens in the absence of policies aimed to reduce barriers to clean energy upgrades for high energy cost burden households.

2.3.1 Baseline and Projected Emissions

Fuel use in residential buildings accounts for only seven percent of Nevada's baseline CO_2 emissions and four percent of the state's NO_x emissions, but about 15 percent of primary $PM_{2.5}$ emissions, largely due to wood burning. NO_x also contributes to the secondary formation of particulate matter and ozone. While these emissions contribute in part to statewide ambient air quality impacts, in-home fuel combustion is of particular concern for indoor air quality. Like ambient air pollution, indoor air pollution is associated with adverse respiratory and cardiovascular health outcomes. Furthermore, the average American spends roughly 90 percent of their time indoors,[94] increasing the potential for adverse exposures.[95]

Natural gas combustion can contribute to significant in-home emissions of carbon monoxide, NO_x, $PM_{2.5}$, and formaldehyde[96, 97, 98] in many types of residences, with concentrations possibly highest in small dwellings like apartments.[99] Leakage of unburned natural gas from appliances, in addition to releasing methane, may also result in increased exposure to known human carcinogens including benzene and other VOCs. There is a lack of research on the magnitude of exposure to health-damaging air pollutants and associated health impacts due to incomplete combustion and natural gas leakage.

94 Klepeis, Neil E., *et al*. The National Human Activity Pattern Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants. *Journal of Exposure Science & Environmental Epidemiology* 11.3 (2001): 231-252.

95 US Environmental Protection Agency. "Indoor Air Quality." Available at: https://www.epa.gov/report-environment/indoor-air-quality#health

96 Seals, Brady and Andee Krasner. Health Effects from Gas Stove Pollution. *Rocky Mountain Institute* (2020).

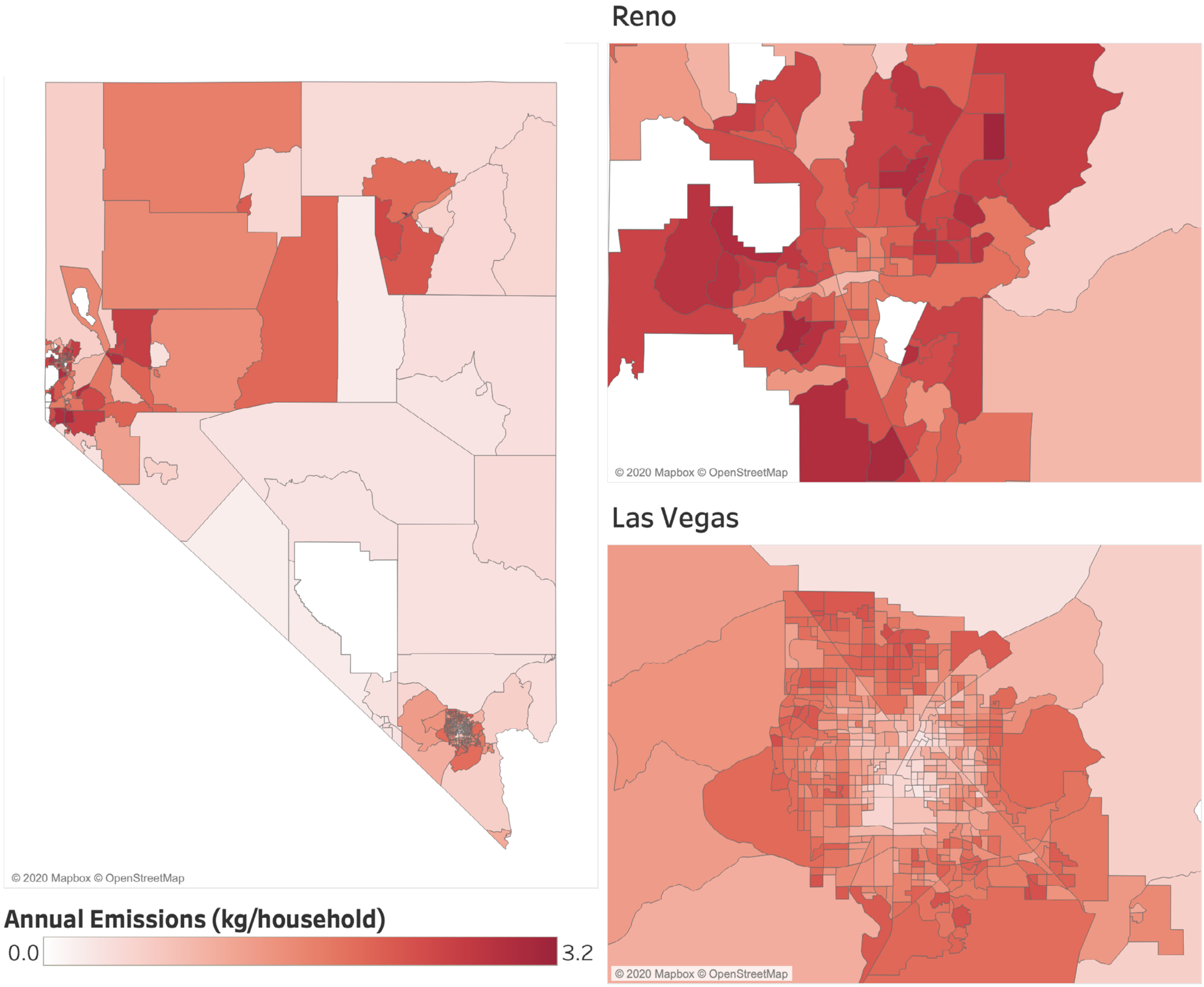
97 Mullen, Nasim A., *et al*. Results of the California Healthy Homes Indoor Air Quality Study of 2011–2013: Impact of Natural Gas Appliances on Air Pollutant Concentrations. *Indoor Air* 26.2 (2016): 231-245.

98 Logue, Jennifer M., *et al*. Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California. *Environmental Health Perspectives* 122.1 (2014): 43-50.

99 Zhu, Yifang, *et al.* Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California. *UCLA Fielding School of Public Health* (2020).

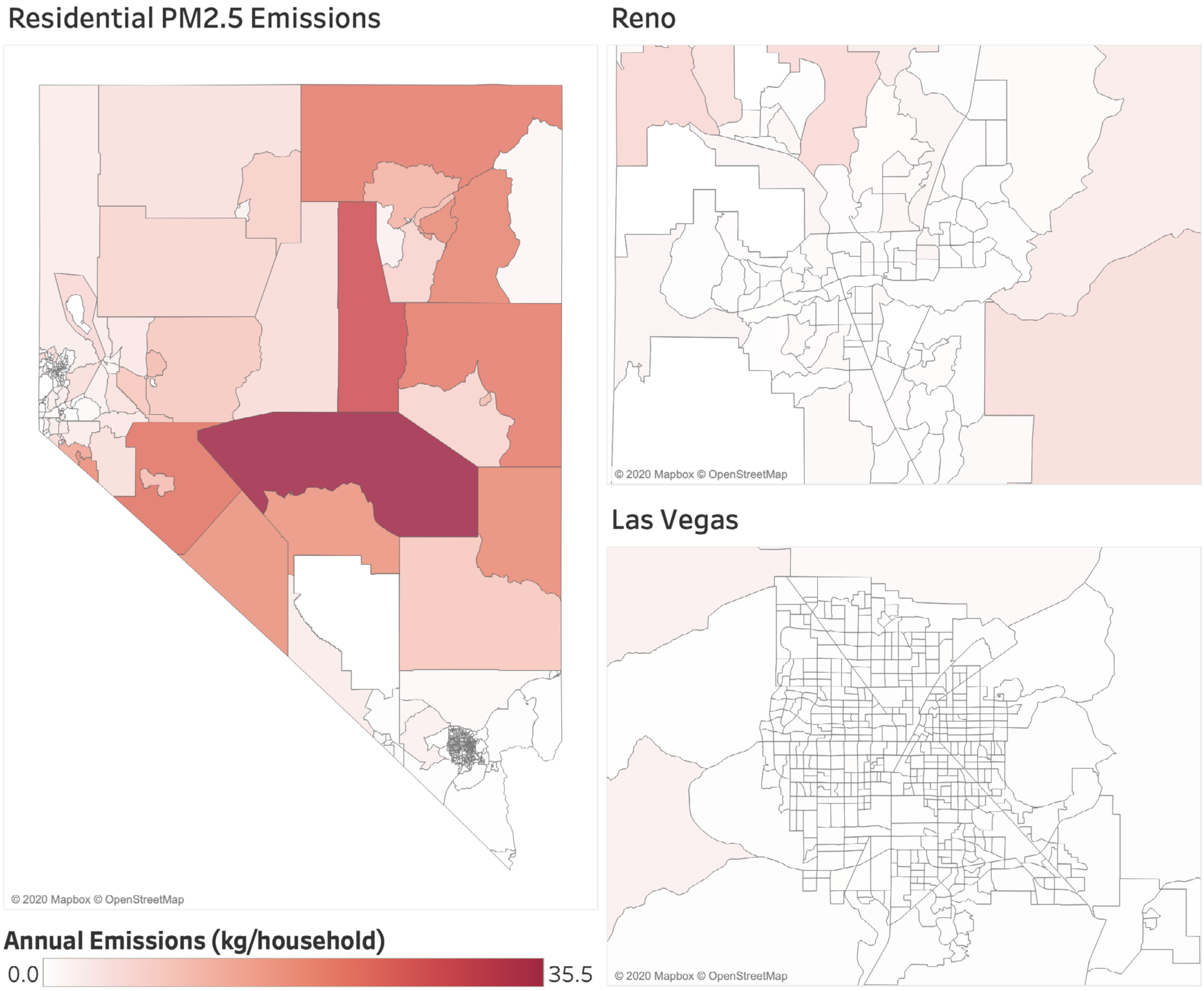
Excluding electricity, which is accounted for in our analysis of the power sector, natural gas dominated Nevada's 2017 residential energy at 91 percent of consumption. Propane accounted for five percent and biomass four percent, making these two fuels the next largest sources of non-electric residential energy. Similarly, natural gas accounted for the largest portion of this sector's CO_2 at 87 percent of emissions while propane comprised five percent and biomass seven percent.[100] Reducing residential carbon emissions therefore requires substantially reducing natural gas use in buildings.

FIGURE 20. Average NO_x household emissions from natural gas by census tract (2017). NO_x emissions from natural gas are highest in urban areas, however almost all areas, including rural, have some NO_x emissions.



100 As noted in the background section, the lifecycle greenhouse gas emissions associated with natural gas use are significantly higher than the CO_2 from combustion alone due to the leakage of methane throughout the natural gas system.

FIGURE 21. Average $PM_{2.5}$ household emissions by census tract (2017). $PM_{2.5}$ emissions are highest in rural areas in the eastern and central portions of the state due to wood burning, and significantly lower in urban areas.



Although natural gas accounts for the majority of residential carbon emissions, its use is clustered in urban and suburban areas (**Figure 20**).[101,102] We note that the downtown parts of Las Vegas have lower residential air pollutant emissions per household compared to surrounding areas, likely due to differences in housing and population characteristics (see next section). The lack of availability of natural gas in rural areas means that many homes in those areas rely on propane and wood. Wood emits several times more $PM_{2.5}$ than natural gas does annually (720 tonnes vs. 140 tonnes statewide) despite generating a fraction of the state's energy, though it is largely constrained to rural regions in eastern and central Nevada (**Figure 21**). About 15,000 households in rural

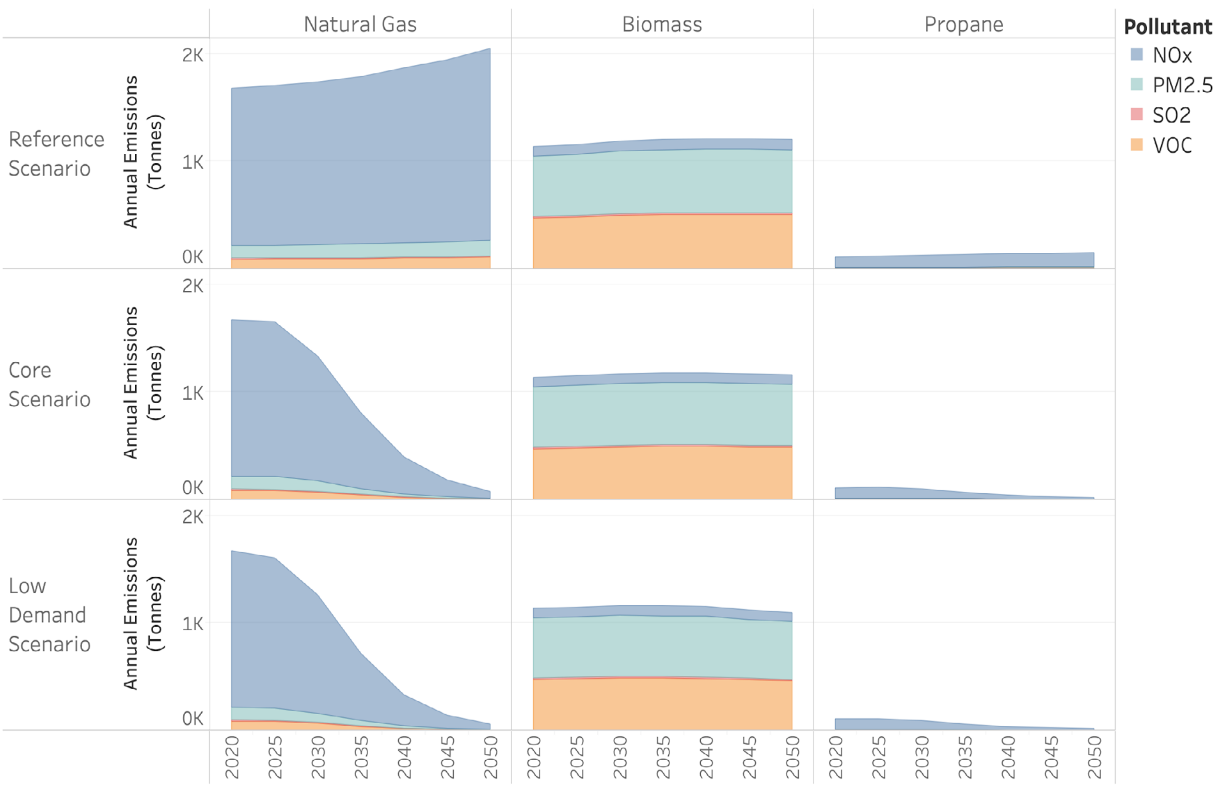
101 US Department of Homeland Security. "Natural Gas Service Territories." Sept. 2017. Available at: https://hifld-geoplatform.opendata.arcgis.com/datasets/natural-gas-service-territories

102 Nevada Public Utilities Commission. "Utility Service Area Maps." Accessed: Nov. 2020. Available at: http://puc.nv.gov/Utilities/Utility_Service_Area_Maps/

Nevada currently use wood as their primary heat source. Decarbonization efforts focused solely on natural gas will therefore risk leaving substantial $PM_{2.5}$ emissions across rural parts of the state.

Our modeled emission projections under the decarbonization scenarios reveal the possibility of leaving behind residential $PM_{2.5}$ emissions in rural Nevada. **Figure 22** below compares projected emissions for the Reference scenario to emissions under the Core and Low Demand scenarios. The other decarbonization scenarios are omitted from the figure for readability, though they show similar patterns to those depicted. For both scenarios shown, natural gas-related emissions begin declining nearly immediately, with emissions reductions speeding up in 2025 and emissions reaching substantially lower levels than baseline by 2050. $PM_{2.5}$, SO_2, and VOC emissions from natural gas start low and reach near-zero levels; and only a small quantity of NO_x emissions remain by 2050. Similar patterns exist for propane, though propane is responsible for a smaller portion of overall emissions at baseline, making the magnitude of emission reduction lower for this fuel.

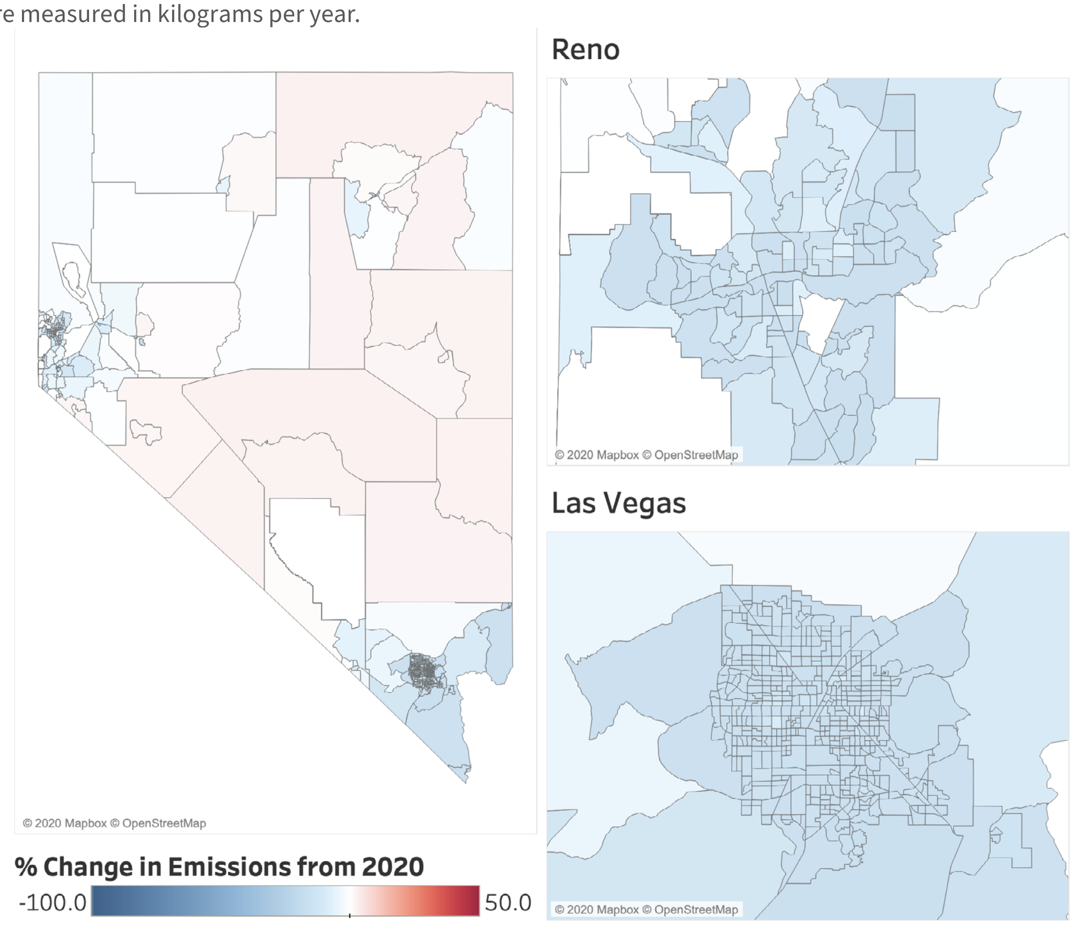
FIGURE 22. Criteria air pollutant emission projections by residential fuel for three decarbonization scenarios. Due to uneven fuel switching, propane and natural gas-associated emissions decline substantially by 2050 while biomass-related emissions (wood) remain relatively fixed. Other scenarios show similar trends.



In contrast to natural gas and propane, wood use and resultant emissions remain relatively constant across scenarios, with little change from baseline to 2050. This trend is the product of the energy system model's assumption that in decarbonization scenarios, natural gas and propane appliances would be the primary targets for fuel switching. $PM_{2.5}$ and VOCs are the major constituents of wood-related pollution and remain high through all projected years, though some SO_2 and NO_x are emitted as well. The high emission rate of wood and continued emissions across scenarios suggest that, absent targeted efforts to reduce wood-related emissions, rural regions of Nevada with above average baseline wood use may continue to contribute relatively high emissions of health-damaging pollutants such as $PM_{2.5}$.

Due to uneven fuel switching across scenarios and geographically clustered use of each fuel at baseline, the spatial distribution of residential air pollution could grow increasingly uneven moving forward. In the Reference case, emissions are projected to increase throughout the state. In contrast, Core scenario projections for 2030 show substantial criteria air pollutant emission reductions in urban and suburban census tracts but also modest increases across rural parts of the state (**Figure 23**). The trends are similar in other scenarios. By 2050, this urban/rural gap largely closes for the Low Demand scenario, which has higher rates of energy efficiency implementation in buildings, but remains in other scenarios. Many rural tracts in 2050 continue to show a small increase in emissions under the Core scenario due primarily to continued use of wood for home heating while urban tracts have largely eliminated emissions. These findings suggest it may be valuable to incorporate considerations for replacing in-home wood use into energy transition strategies.

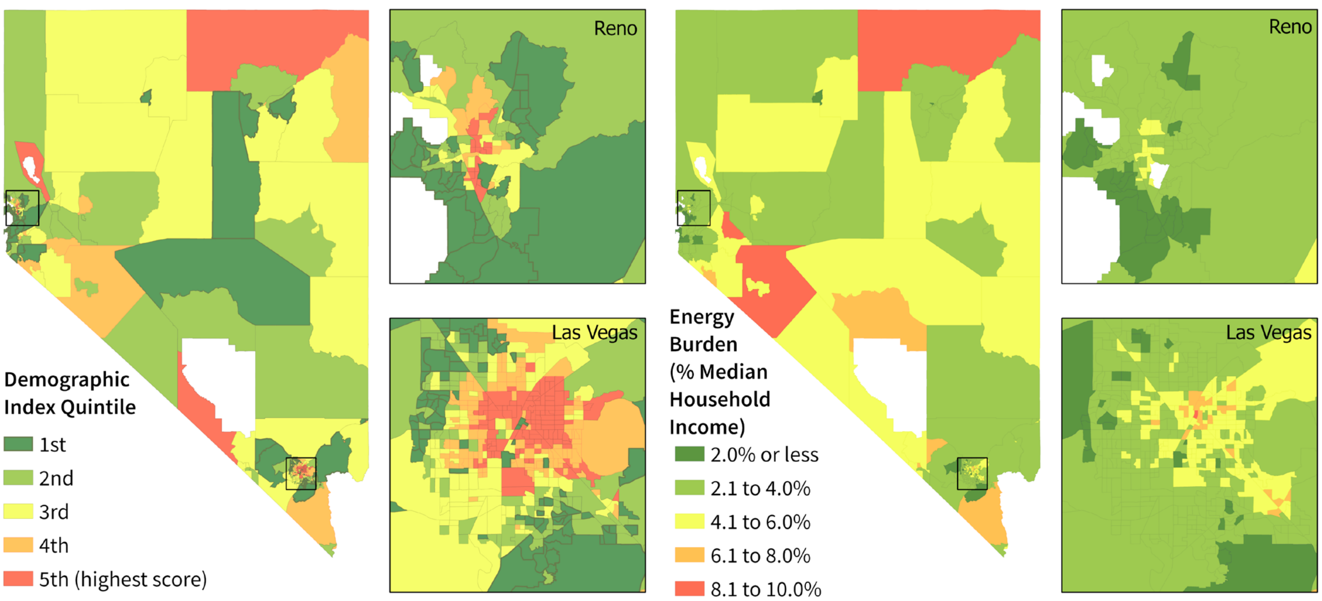
FIGURE 23. Census tract projected 2030 criteria air pollutant emissions change for the Core scenario. In the medium term, the Core Scenario leads to emission reductions, though these are largely confined to urban and suburban areas—many rural areas experience slight residential emission increases. Pollutants included are NO_x, $PM_{2.5}$, SO_2, and VOCs. All pollutant emissions are measured in kilograms per year.



2.3.2 Household Energy Cost Burdens

The spatial distribution of residential energy cost burdens in Nevada closely follows the state's geographic trends in demographic and environmental vulnerability. **Figure 24** shows the Demographic Index (left) and average household energy cost burden (right) by census tract in Nevada. Several of the highest energy cost burden census tracts are located in rural parts of the state. In addition, the Reno and Las Vegas downtown areas show a significant overlap between higher energy cost burden and higher scores on the Demographic Index. These socioeconomically overburdened communities are also exposed to higher environmental pollution burden compared to other parts of the state, as highlighted in **Figure 3** in the Introduction.

FIGURE 24. Integrated Demographic Index and average household energy cost burden by census tract for Nevada, Reno, and Las Vegas. In the Demographic Index, orange/red neighborhoods have a higher share of combined low-income, minority, low educational attainment, linguistically isolated, elderly, and very young populations compared to other census tracts in Nevada. In the energy burden map, orange/red neighborhoods have higher average household energy cost burdens.



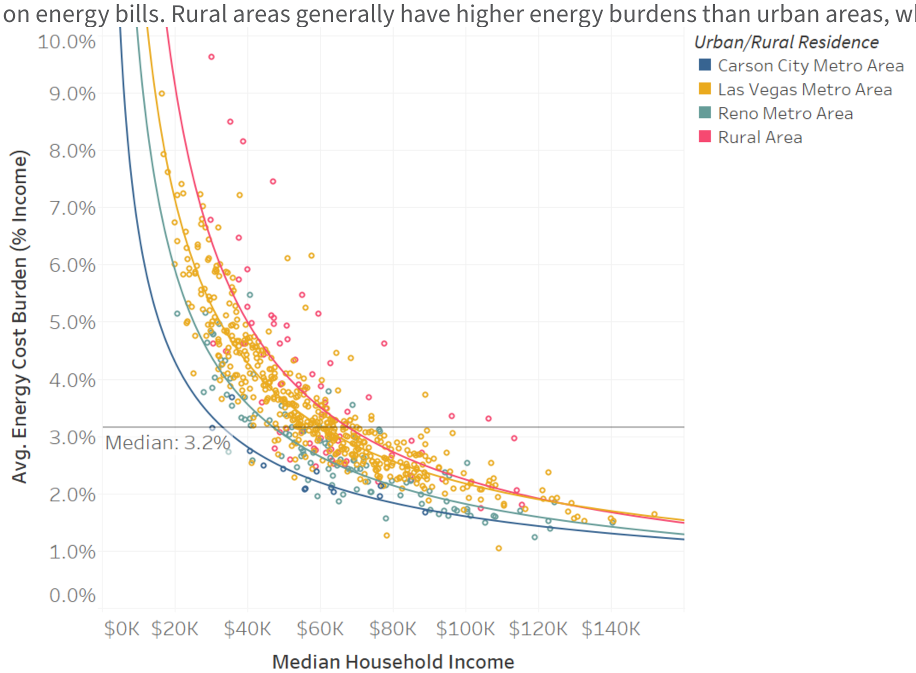
2.3.2.1 Household Energy Cost Burden: Income Analysis

Similar to the transportation sector, residential energy cost burdens are inversely correlated with household income. **Figure 25** shows that on average, households in the lowest income census tracts spend an appreciably higher percentage of their annual income on energy bills (maximum ~ 9.5 percent) than most others (median ~ 3.2 percent).[103] At the same time, household income is positively correlated with energy consumption, with higher income households consuming more energy on average with more natural gas as a fraction of total energy use (**Figure 26**). Energy cost burdens tend to be highest in rural areas; and among urban areas, Las Vegas energy burdens are highest on average.

These broad rural and metro area trends are based on average values, and we identified neighborhoods within these areas with substantially higher energy burdens than their neighbors. For example, West Las Vegas census tracts have average energy burdens approximately 1.5 percent higher than the Vegas Metro Area at large. It is notable that West Las Vegas in particular has higher energy burdens than its surroundings, as this area was subject to Jim Crow-era segregation and significant disinvestment for most of the 20th century.[104] This highlights the importance of designing residential decarbonization policies which facilitate investment in communities that have historically experienced economic disinvestment to improve social equity.

Based on our findings, policy strategies to reduce per-household energy consumption may maximize economic and public health co-benefits if tailored towards low-income households. Conversely, strategies which primarily target households with large carbon footprints and do not explicitly target populations with the highest energy burdens may disproportionately benefit the least economically vulnerable households and exacerbate existing socioeconomic disparities. Carbon reduction and energy cost burden mitigation goals do not have to be mutually exclusive, and it is critical for policies to be structured in ways that achieve both objectives.

FIGURE 25. Census tract average energy cost burden.[105] Lower income households tend to spend a much greater proportion of their income on energy bills. Rural areas generally have higher energy burdens than urban areas, while Las Vegas energy burdens are h

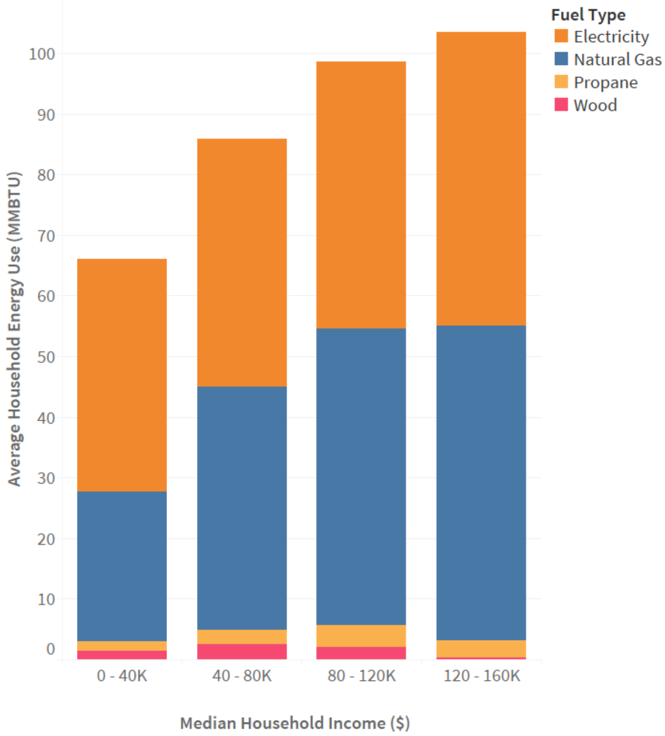


103 These values reflect estimated *average* energy cost burdens by census tracts. Some individual households within these tracts may have significantly higher energy cost burdens, and some will be lower.

104 City of Las Vegas. "West Las Vegas Plan." July 2009. Accessed Dec. 2020. Available at: https://files.lasvegasnevada.gov/planning/West-Las-Vegas-Plan.pdf

105 Rural areas refer to all census tracts that are not designated as metropolitan statistical areas by the US Census Bureau. This includes micropolitan statistical areas (at least one urban cluster of at least 10,000 but less than 50,000 population), as well as census tracts that are neither metropolitan or micropolitan.

FIGURE 26. Census tract average energy use and median household income. Higher income households tend to use more energy on average. Decarbonization strategies which solely focus on greenhouse gas emissions reductions may therefore exacerbate existing inequities.



2.3.3 Household Energy Cost Burden: Demographic Analysis

In addition to being higher in lower income communities, energy cost burdens tend to be higher on average in communities of color, which here are defined as census tracts where the largest racial group is Hispanic/ Latin, Black, Asian American, or Indigenous. Although population fraction of color and median household income are negatively correlated, this relationship alone does not account for disparities in energy cost burden; both lower income communities of color and higher income communities of color tend to have higher energy burdens than their White[106] counterparts (**Figure 27**). Communities of color may therefore face higher energy burdens on average.

Our data suggest that higher energy burdens in communities of color may be partially due to variable use rates of different residential fuels with different prices (**Figure 28**). We found that as census tract percent people of color increased, total energy consumption decreased and share of household energy consumption comprised of electricity increased. Elevated reliance on electricity relative to whiter neighborhoods may help reduce indoor air pollution burdens from fuel use in neighborhoods of color, providing some pollution relief for these communities, which generally face higher environmental burdens. At the same time, electricity is more expensive than natural gas, propane, and wood at our baseline analysis year (2018)—and these energy prices may be one partial explanation for the higher cost burdens observed in communities of color. This trend suggests that decarbonization strategies which focus on electrification alone and do not include bill-reducing efficiency measures may fail to provide bill relief for communities of color with high baseline energy cost burdens. Energy efficiency incentives may prove useful for reducing costs for all households, though particularly so for communities of color and other groups with high reliance on electricity, which may be underrepresented in decarbonization efforts if the sole focus is fuel switching.

106 Throughout this report, we use the term "White" to refer to non-Hispanic White populations.

FIGURE 27. Energy Cost Burdens in Nevada by Income and Race. Census tract energy burdens decrease with increasing median income regardless of race; though majority White neighborhoods have lower cost burdens than neighborhoods with majority Hispanic/Latin, Black, Asian American, or Indigenous populations. This is true across quintiles even though intra-quintile income differences are relatively small (**Figure 29**). Though we aggregate people of color into one group to increase sample size and readability, these patterns likely vary by racial group and policies should accordingly be informed by community-specific engagement.

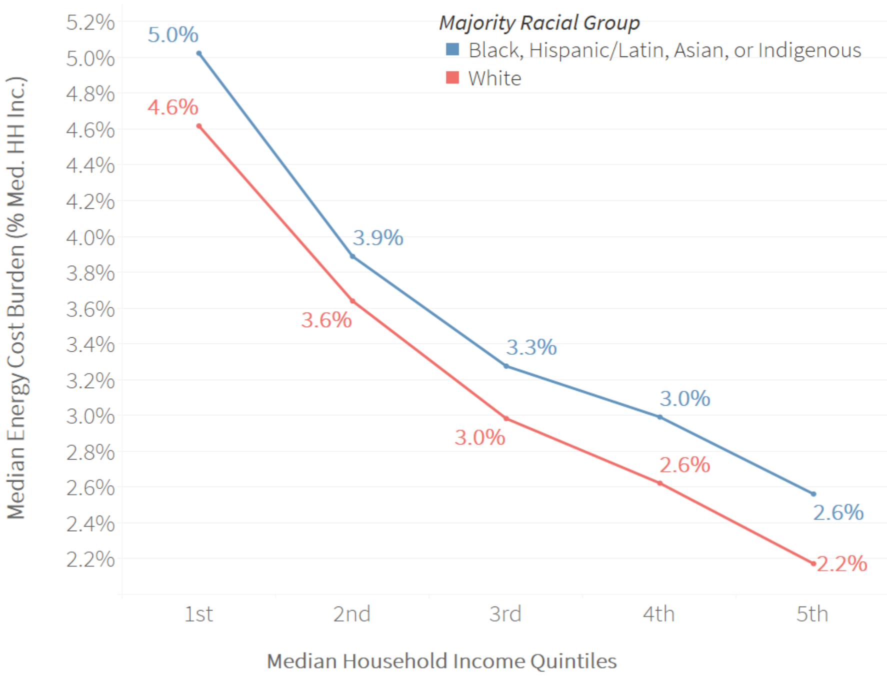
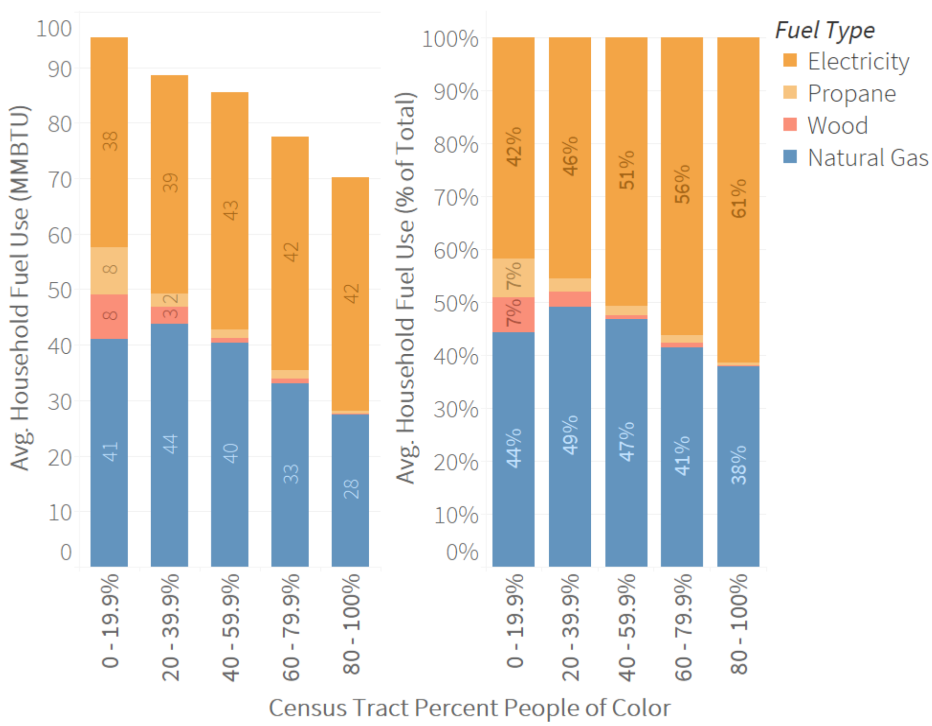


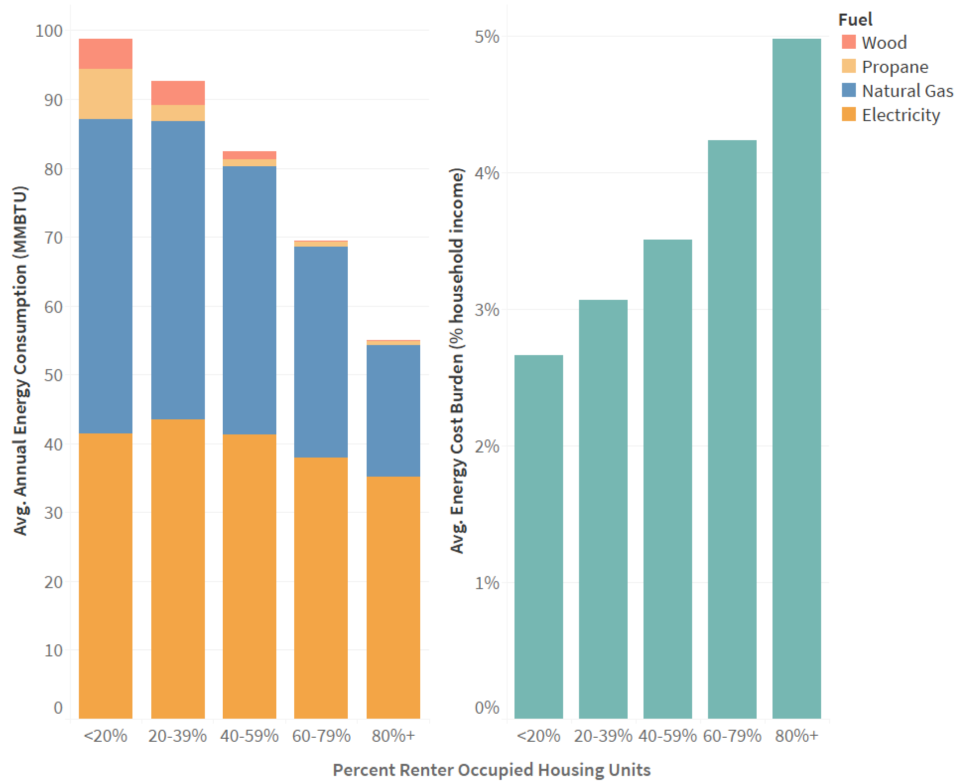
FIGURE 28. Census Tract Racial Composition and Fuel Use Breakdown. As census tract percent people of color increases, total energy consumption generally decreases and electricity as a percent of consumption increases. Electricity is the most expensive fuel in Nevada at baseline. Decarbonization measures beyond fuel switching are therefore helpful to provide bill relief for communities of color (i.e. Hispanic/Latin, Black, Asian American, or Indigenous), which on average have higher cost burdens than White neighborhoods.



As the State establishes policies to increase clean energy access for low-income populations, communities of color, and other bill burdened groups, it is important to devise strategies that include renters. Clean energy policies which are only open to homeowners risk excluding a large portion of Nevada's population: approximately 45 percent of Nevada's housing units are renter occupied, compared to 36 percent in the US. Moreover, similar patterns to those discussed for low-income households and communities of color hold for renters—energy consumption tends to be lower and energy cost burdens higher where large portions of the population rent (**Figure 29**).

At present, many Nevada residential weatherization policies preferentially target owner-occupied homes (see **Section 3.3.2**). Landlords therefore remain prone to the split incentive problem and may be less likely to invest in energy efficiency and clean energy improvements. The State has an opportunity to enact new policies which improve clean energy and energy efficiency access for bill-burdened households by expanding renter eligibility for weatherization programs and implementing bill-stabilizing initiatives such as community solar in neighborhoods with a high proportion of renters.

FIGURE 29. Renter Populations, Energy Use, and Cost Burdens. On average, energy consumption is lower but energy burden is higher in census tracts where a greater portion of the population rents. Decarbonization policies can therefore be made more equitable if they are inclusive of renters.



Exacerbation of wealth disparities between renting and home-owning households could also disadvantage low-income households and communities of color. In Nevada, homeownership is higher in higher-income neighborhoods. This suggests homeowner-centric policies may provide little benefit for lower income communities. Additionally, homeownership is generally lower in communities of color, particularly Black and Hispanic/Latin communities, as compared to White communities of similar socioeconomic status (**Figure 30**). For example, in the lowest income quintile, White neighborhoods have roughly 27 percent higher homeownership rates than Hispanic/Latin, Black, Asian American, or Indigenous neighborhoods despite having an average income less than one percent higher. Similar disparities exist for all quintiles except the middle quintile, suggesting that both lower and higher earning Hispanic/Latin, Black, Asian American, or Indigenous communities own homes at lower rates than White neighborhoods earning similar amounts.

The above findings are based on census-tract level numbers. At the household level, racial disparities in homeownership are greatest for Black Nevadans, 29 percent of whom own their homes, compared to 63 percent of White households. Latinos and Native Americans are also less likely to own the homes they live in. Discriminatory housing policies and practices,[107,108] racially targeted lending,[109,110] and other factors, both historic and contemporary, may help explain these disparities. Due to the observed homeownership gap, policies which disproportionately benefit homeowners or altogether exclude renters risk further institutionalizing wealth disparities between White communities and Hispanic/Latin, Black, Asian American, or Indigenous communities. Carbon reduction and energy cost burden mitigation goals do not have to be mutually exclusive, and it is critical for policies to be structured in ways that achieve both objectives.

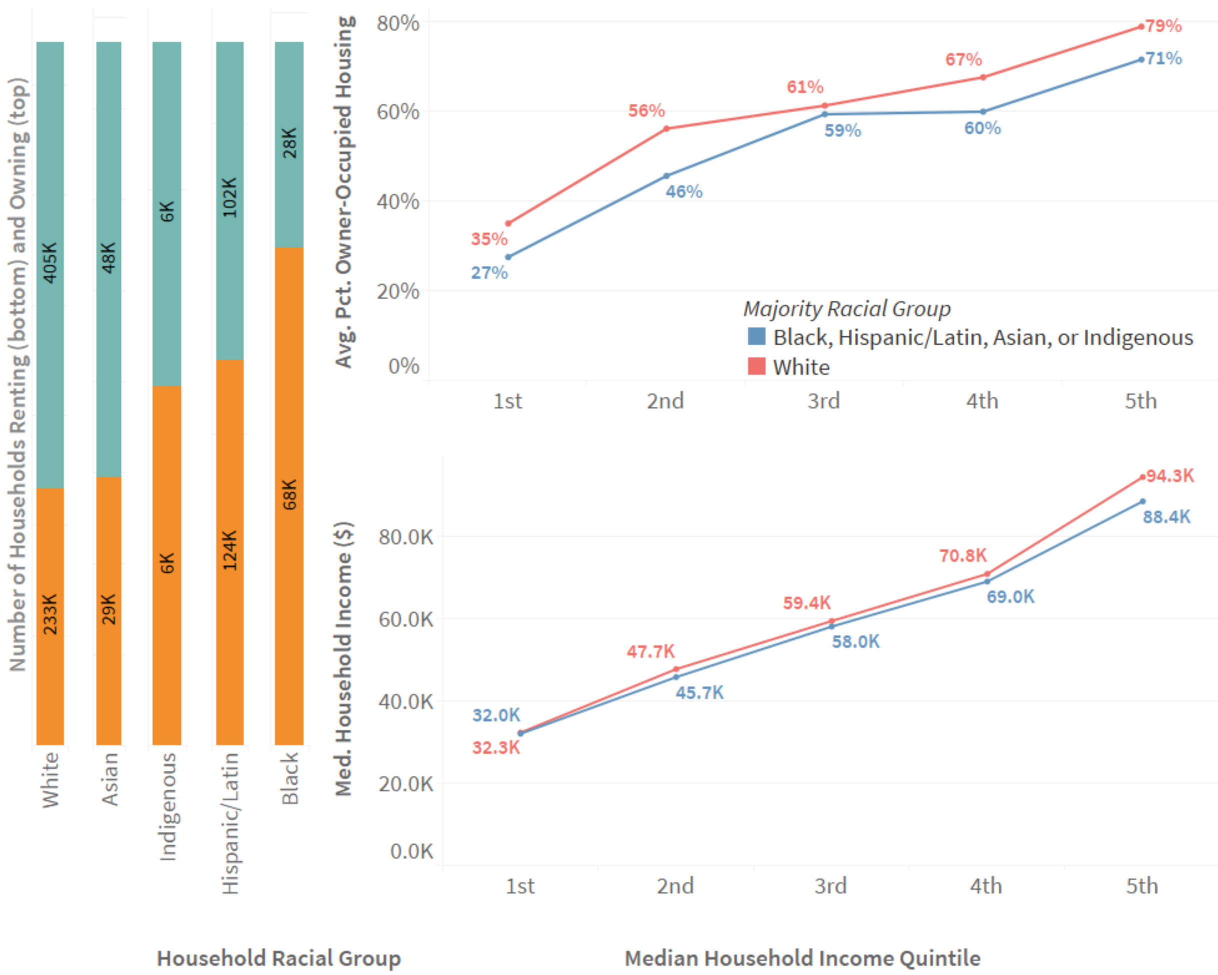
107 Nevada Humanities. "African Americans in Las Vegas." Accessed Nov. 2020. Available at: http://www.onlinenevada.org/articles/african-americans-las-vegas

108 Washoe County, NV. "Washoe County Recorder, Kalie Work, Celebrates SB 117." Oct. 2019. Available at: https://www.washoecounty.us/outreach/2019/10/2019-10-09-county-recorder-sb117.php

109 Reid *et al.* "Revisiting the Subprime Crisis: The dual Mortgage Market and Mortgage Defaults by Race and Ethnicity." *Journal of Urban Affairs* 39.4 (2017): 469-487.

110 Boehm *et al.* "Rates and Race: An Analysis of Racial Disparities in Mortgage Rates." *Housing Policy Debate* 17.1 (2006): 109-149.

FIGURE 30a. Homeownership by Household Race. White and Asian American households are most likely to own their homes while Black households rent at higher rates than any other racial group in Nevada, and **Figure 30b**. Homeownership by Neighborhood Race. Across most income quintiles, median household income is comparable for Black/Brown and White neighborhoods, though communities of color tend to have lower homeownership rates.

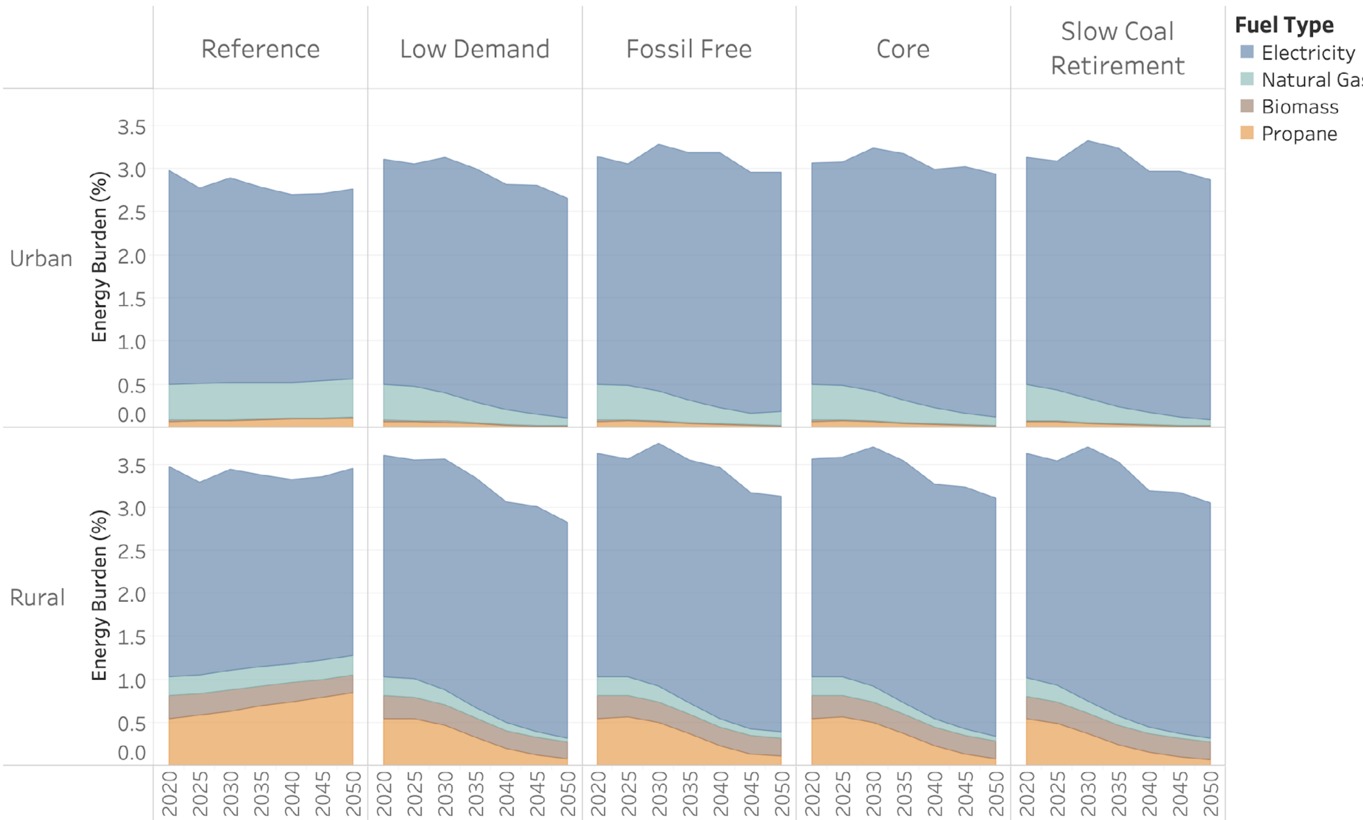


2.3.4 Energy Cost Burden Projections

Although residential fossil fuel-focused decarbonization strategies result in significant overall emission reductions (more so in urban than rural areas), median household energy cost burdens are projected to remain relatively flat on average or decrease slightly in some decarbonization scenarios (**Figure 31**). This result may be due in part to the fact that electricity is already the largest contributor to residential energy cost burdens in Nevada. While residential electricity rates are projected to increase under decarbonization scenarios, overall residential energy use per household is projected to decrease due to the higher efficiency of electric heat pumps and the implementation of other energy-saving measures. Thus, the gradual curtailment of propane use in rural areas and natural gas use in urban areas and their replacement with electric heating will not have a substantial impact on overall energy burden. Our analysis of energy cost burden reflects median values for each census tract and focuses on broad geographic patterns, though individual households may face higher energy cost burdens.

On average, rural households will continue to experience higher energy cost burdens, although the gap between rural and urban households is projected to decrease. Under the Slow Coal Retirement, Core, and Fossil Free scenarios, urban and suburban area energy cost burdens stay relatively constant but rural energy expenditures relative to household income decrease by close to half a percentage point. Under Low Demand, rural households experience the largest decrease in energy cost burden, and urban and suburban energy cost burdens also decrease on average—making this scenario the most beneficial overall for reducing energy cost burdens.

FIGURE 31. Percent change in projected energy cost burden by scenario for urban and rural areas. Rural areas tend to have the largest decreases in energy cost burden across scenarios, though urban and suburban areas also experience decreases under certain scenarios.



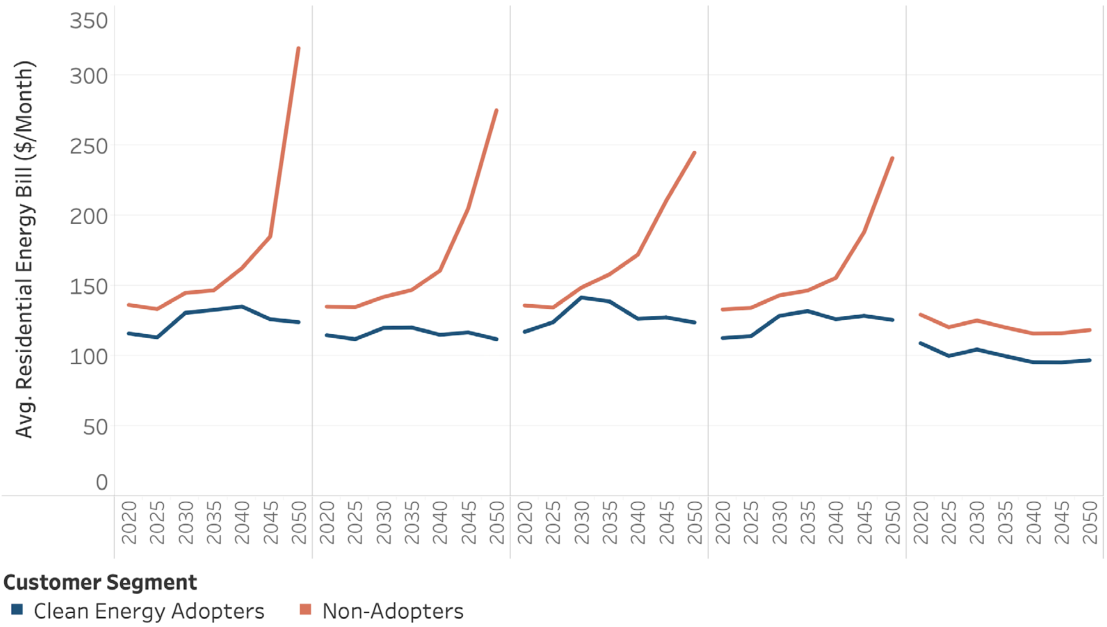
2.3.5 Bill Impacts

While residential decarbonization presents opportunities to alleviate existing social and economic inequities, if not intentionally designed to do so, there is instead a possibility of exacerbating economic impacts on populations with already high energy burdens. The Evolved model for each scenario assumes that a certain percentage of households are included in decarbonization efforts and adopt some combination of clean energy technologies such as electrification and energy efficiency measures, leaving the remaining households with less efficient appliances and with pollutant-emitting fuel sources such as natural gas.

Natural gas use is largely phased out across the state according to a timeline which varies by scenario, but some households continue using natural gas past 2040 even as other homes switch most residential energy consumption to electricity. Should a non-systematic approach to electrification be implemented, households which continue to use gas would likely be located throughout the state, and the entire gas distribution system would have to remain in-place to avoid energy disruption to these homes. Under this situation, the cost of maintaining distribution systems would remain relatively fixed and be distributed among fewer and fewer users.

Figure 32 illustrates how distributing these costs among fewer households has the potential to lead to significant energy bill increases for households which do not transition to clean energy technologies. Monthly bills are consistently higher for households who do not electrify or otherwise install clean-energy technologies (non-adopters) than those that do (adopters) over time, but the gap between the two groups varies between 2020 and 2050. For all scenarios, non-adopters' bills are only moderately higher than those of clean energy adopters until roughly 2035-2040, at which time they increase dramatically to cover the cost of maintaining remnant gas infrastructure. This trend is particularly true of the Fossil Free and Slow Coal Retirement scenarios, where non-adopting households could see their energy bills increase by as much as 100 percent. Though projected energy bill increases are highest for non-adopting households under the Fossil Free and Slow Coal Retirement scenarios, all scenarios yield some monthly bill increase relative to the Reference Scenario by 2050, including for clean energy adopters. This increase is smallest for clean energy adopters under the Low Demand Scenario, where energy bills remain relatively flat due to higher implementation of energy efficiency measures.

FIGURE 32. Change in monthly aggregate energy bills for electricity and in-home natural gas for clean energy adopters of electrification and energy efficiency measures versus non-adopters, over time. Households which do not adopt clean energy technologies may face skyrocketing utility bills by mid-century absent policy interventions, particularly under the Fossil Free and Slow Coal Retirement scenarios.



This type of analysis raises important questions about the future of the gas distribution system post-2040 and how to prepare in the coming decades to maximize economic co-benefits and minimize adverse bill impacts to non-adopting, socioeconomically vulnerable groups in the 2040-2050 timeframe. Our findings underscore the importance of policy interventions that provide utility bill protections and increase clean energy accessibility for non-adopting and high energy cost burden households and households which may have otherwise have been non-adopters.

In addition, these findings suggest that gas infrastructure maintenance may become challenging for gas utilities past 2040 as the residential sector decarbonizes and demand and revenue decrease. A residential gas distribution system will be difficult to maintain if costs are passed onto fewer and fewer remaining customers, in which case fuel switching may happen even faster than assumed due to economic pressures on consumers post 2040 (especially among those with the financial means to finance their own fuel switching). The system may also be difficult to maintain should gas utilities have to absorb these costs to keep their remaining customers. Therefore, a managed and geographically targeted phase-out of the gas distribution system from one region to the next (one region entirely phased out at a time), may have to be considered to mitigate potential economic impacts by gradually reducing fixed maintenance costs.

2.3.6 Climate Resilience and Targeted Deployment of Distributed Energy Resources

Clean energy deployment in certain population subsets may be particularly beneficial to reduce energy cost burdens and provide resilience. Rooftop solar, for example, can provide utility bill stability and economic savings for high energy cost burdened households, such as populations of color, renters, and low income populations. Approximately 1.0 gigawatts of solar capacity would be required to completely match very low-income households' 2030 energy needs. This number increases to roughly 2.5 gigawatts for low-income households. These same households would likely benefit from energy-saving efficiency measures.

Similar focused deployment strategies are possible to target different populations in a way that maximizes economic, public health, and community resilience benefits. The Core decarbonization scenario projects approximately 12.2 gigawatts of total solar capacity across the state by 2030, 1.3 gigawatts of which are rooftop solar. Table 3 shows approximately what portion of this capacity would be required to completely cover 2030 energy needs for various demographic groups. The groups shown in this table may reap particularly high resilience and economic co-benefits from clean energy measures due to socioeconomic, geographic, and health-based vulnerabilities. Though the population subgroups in this table are approximate and do not show all groups which may benefit from clean energy deployment, they conceptually illustrate that strategic policies which make solar and other clean energy technologies accessible to these populations may maximize the co-benefits of decarbonization. Policymakers may therefore wish to consider co-benefits when balancing deployment of distributed energy resources such as solar + storage, community solar, and energy efficiency measures versus utility-scale solar projects.

Rural households, for example, and customers who rely on electricity for medical needs may particularly benefit from the resilience and reliability of home solar + storage systems which can provide backup in case of grid outages. Urban households living in apartment buildings might benefit from the fuel savings of energy efficiency measures and utility bill stability from community solar programs. Low-income households living in areas with high extreme heat days—projected to increase with climate change (**Figure 33**)—may face trade-offs between affording their electric bills and risking health complications such as heat stroke,[111] acute cardiovascular and respiratory episodes (including premature death),[112] and poor mental health outcomes.[113] Affordable, reliable access to air conditioning and air filtration may help mitigate

111 Wu *et al.* Emergency Department Visits for Heat Stroke in the United States, 2009 and 2010. *Injury Epidemiology* 1.1 (2014): 8.

112 Barnett, A. G., *et al.* Cold and Heat Waves in the United States. *Environmental Research* 112 (2012): 218-224.

113 Basu *et al*. Examining the Association Between Apparent Temperature and Mental Health-Related EMergency Room Visits in California. *American Journal of Epidemiology* 187.4 (2018): 726-735.

such outcomes.[114] Nevada municipalities such as North Las Vegas require air conditioning in residential buildings, implicitly acknowledging the importance of air conditioning in preventing adverse, heat-related health outcomes. North Las Vegas and other cities considering similar policies can make these health-protective ordinances more effective by promoting reliability of requisite air conditioning systems with resilient energy technologies.

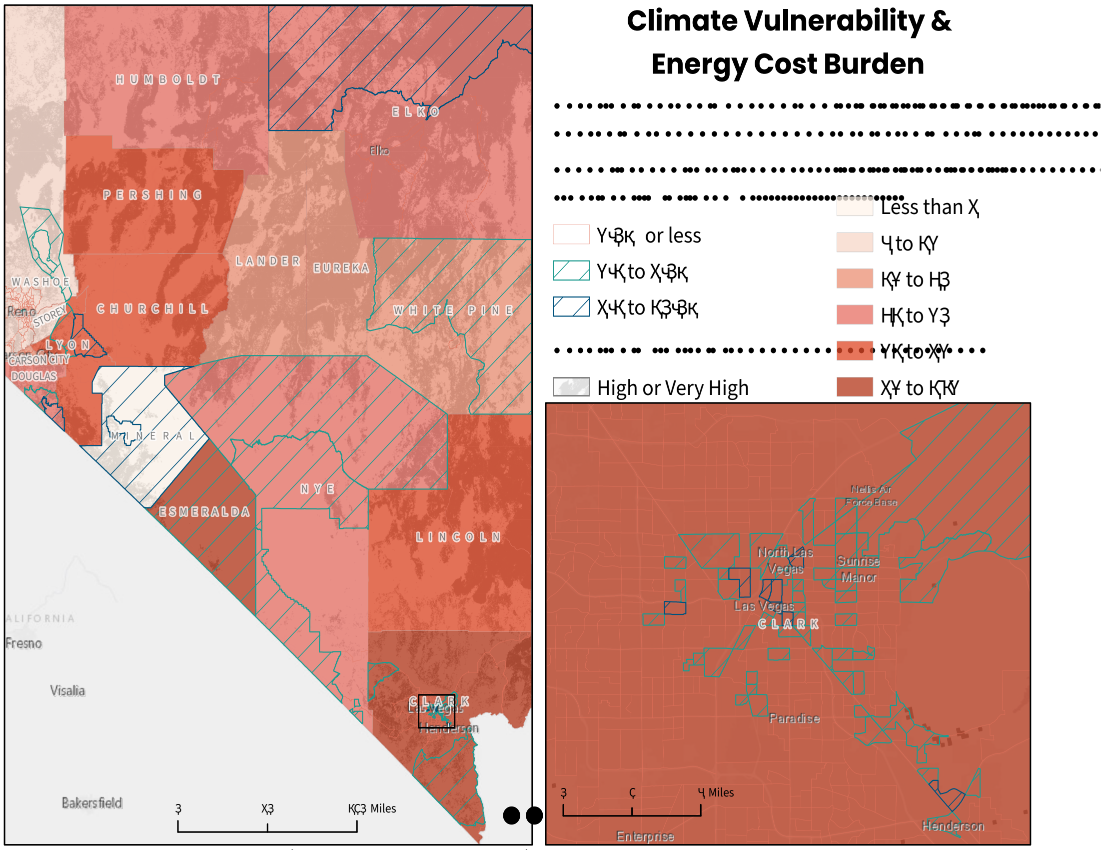
Low-income households in areas with high fire risk (or downwind from such areas) may similarly benefit from improved access to air filtration and increased electricity reliability during natural disasters. Distributed solar + storage systems and microgrids at facilities such as gyms, schools, and community centers can help these locations serve as resilience hubs and help meet cooling, cell phone charging, air filtration, and even evacuation needs. Distributed solar + storage and microgrids can also provide resilience to key facilities such as medical clinics and fire stations.

TABLE 3. Approximate solar capacity required to meet demand for socioeconomic, geographic, and health-based vulnerable populations by 2030 under the Core Scenario.

Population Subset	Projected Number of Households	Solar Required to Meet Projected 2030 Electricity Needs (Core Scenario)		
		Total GW	% of Total Solar in 2030 (12.2 GW)	% of Rooftop Solar in 2030 (1.3 GW)
Total Nevada Households	1,240,000	9.2	75%	708%
Base Demographic & Geographic Groups				
Very Low-Income Households (below Federal poverty line)	185,000	1.0 GW	8%	78%
Low-Income Households (below double Federal poverty line)	455,000	2.5 GW	20%	192%
Rural Households	18,500	0.1 GW	<1%	8%
Projected Extreme Heat County Households (90th percentile annual days over 95˚F)	914,000	5.8 GW	46%	446%
Medical Baseline Customers	37,000	0.2GW	2%	15%
Combination Demographic & Geographic Groups				
Low-Income, Rural Households	6,100	0.03 GW	<1%	2%
Medical Baseline Customers in Heat Counties (50th percentile annual days over 95˚F)	27,000	0.2 GW	2%	15%

114 Ostro *et al.* The Effects of Temperature and Use of Air Conditioning on Hospitalizations. *American Journal of Epidemiology* 172.9 (2010): 1053-1061.

FIGURE 33. Projected extreme heat days, wildfire risk, and average household energy cost burdens. Portions of Nevada may experience frequent heat days by mid-century (days over 95˚F); and much of the state has high or very high wildfire risk. A warming climate and intensifying wildfires may exacerbate energy cost burdens for Nevadans due to increasing air conditioning and filtration needs.



Source Data: Kopp Group, Rhodium, Projected Days over ... RCP, Median Probability; US Census Bureau, IPUMS NHGIS, Average Household Income; EIA SEDS, Fuel Prices; Min et al., PSE, Residential Energy Modeling; USDA, Fire Risk

2.4 Commercial Buildings

According to the US Energy Information Administration, the commercial sector accounted for 2.4 megatonnes of CO_2 emissions in Nevada in 2017, or seven percent of the cross-sectoral state total related to energy. Nevada's commercial sector CO_2 emission growth rate over the last several decades is the largest in the country, with a 200 percent increase from 1980 levels compared to an average six percent decrease nationwide.[115] This high growth rate suggests that commercial sector decarbonization is important to statewide goals. However, we were unable to locate or derive commercial emissions data at finer spatial resolution than the county level, which we obtained from the National Emissions Inventory (NEI).[116] Lack of spatially granular commercial data does not preclude further decarbonization efforts, but presents difficulties in ensuring decarbonization policy is designed to maximize health and economic co-benefits where they are most needed. There is accordingly a strong need for more rigorous reporting and characterization of commercial emissions data.

Of the fuels included in the NEI dataset, natural gas produces the most criteria air pollutant emissions statewide (see **Figure 34**). Emissions also result from burning fossil fuels such as gasoline, fuel oil, propane, and biomass, though to a lesser extent. Without census-tract or facility-level data, it is not feasible to ascertain the distribution of these fuels across geographic space and commercial facility types. The only industry with emissions characterized in the dataset is commercial cooking. However, many of these emissions come from the act of cooking itself,[117] which results in emissions of pollutants such as $PM_{2.5}$ and VOCs due to the chemical processes that occur during cooking, as opposed to fuel burning for the purposes of cooking.

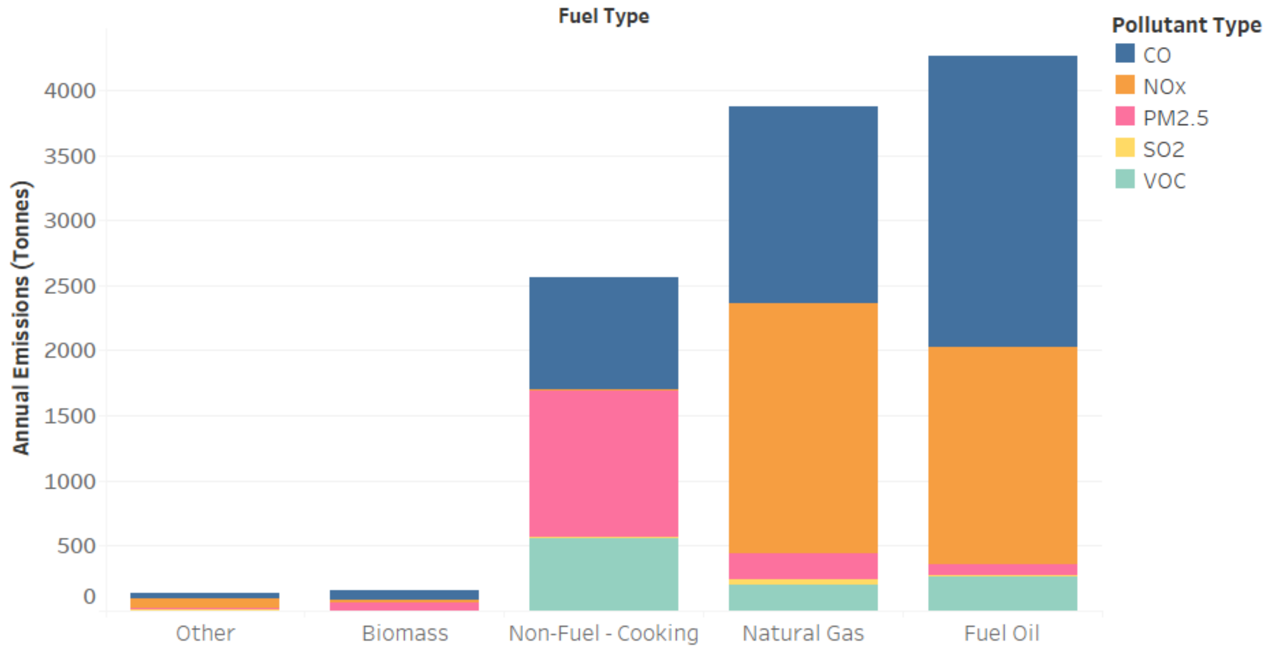
Based on the available data, the state should initiate fuel switching initiatives to replace use of natural gas, gasoline, propane, and other emitting fuels with clean electricity in the commercial sector. Furthermore, the State may be better able to develop targeted policy initiatives with more detailed information, and data collection efforts are warranted. This is especially important in areas with high cumulative emission burdens from other sectors. For example, the Las Vegas strip has high emission burdens from the transportation sector; and may also have a high commercial emission burden due to the abundance of large casinos. Data collection efforts in areas like this may be especially valuable for informing policies which address the needs of environmentally burdened communities.

115 US Energy Information Administration. "2017 State Energy-Related Carbon Dioxide Emissions by Sector." May 20, 2020. Available at: https://www.eia.gov/environment/emissions/state/

116 The National Emissions Inventory reports state commercial sector emissions but is incomplete.

117 US Environmental Protection Agency. 2017 National Emissions Inventory Complete Release - Technical Support Document (2020).

FIGURE 34. Commercial sector criteria pollutant emissions (2017). "Other" includes gasoline and propane. Data are limited, though commercial use of natural gas, gasoline, propane, and fuel oil emit criteria air pollutants and precursors. Electrification can reduce fuel use and associated emissions. More data will help develop well-targeted decarbonization strategies for the commercial sector.



2.5 **Electricity Generation**

Nevada currently has 21 natural gas, coal, oil, and biofuel power plants—facilities reliant on fuels which release greenhouse gases and criteria air pollutants when combusted. Of these, 16 burn natural gas, two burn coal (with oil as a secondary fuel), two burn landfill gas, and one small facility burns oil. The natural gas plants generate 93 percent of the electricity supplied by all of these facilities. Natural gas and coal power plants supply 71 percent of the total electricity generated in-state, while solar, geothermal, and hydropower generate most of the remainder.

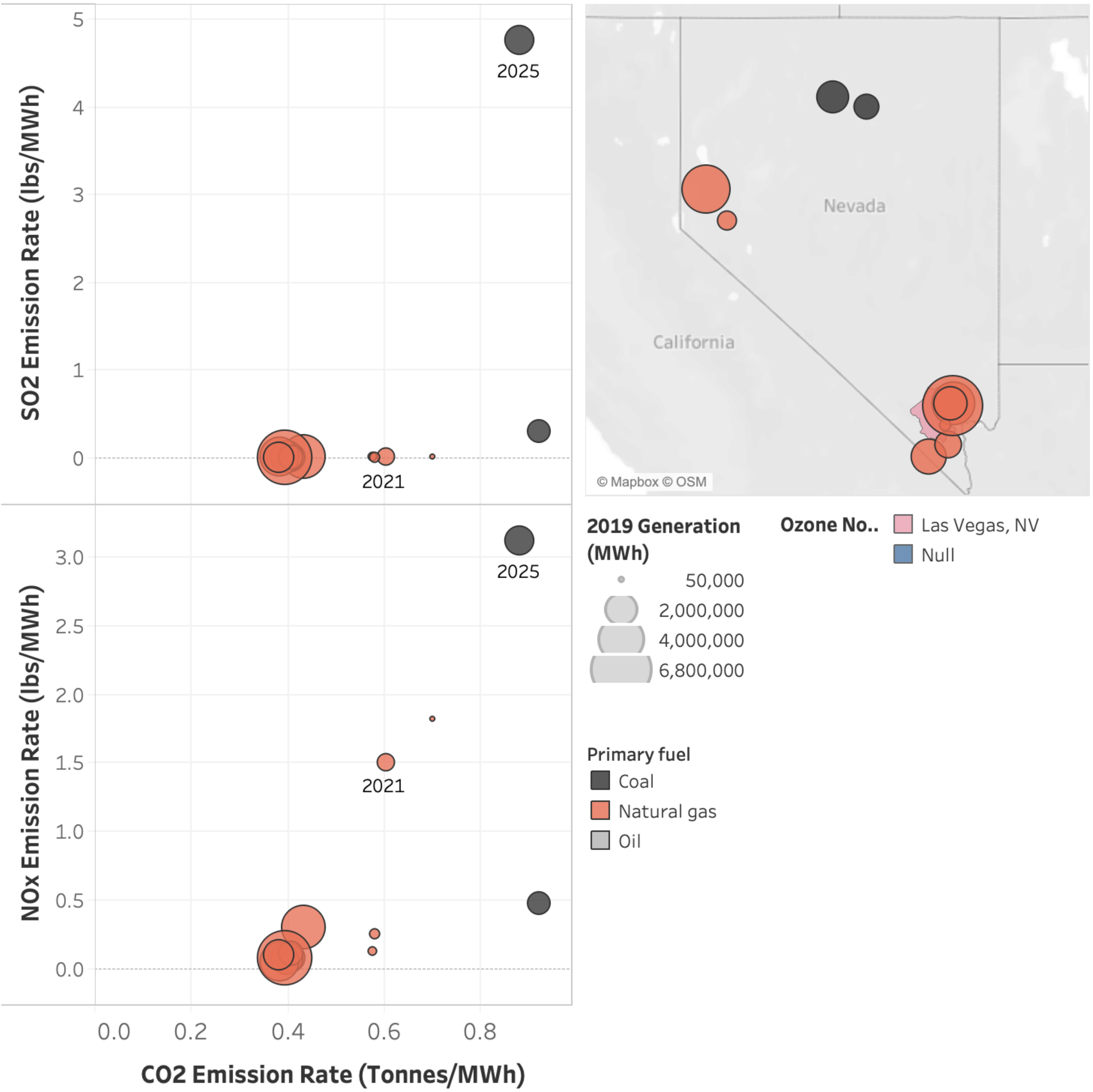
Nevada's coal plants are located in the rural northern part of the state and are largely used to supply the electric load associated with mining activities in the region. These two plants generate seven percent of the state's fossil fuel electricity, but produce 16 percent of electricity-related CO_2, 23 percent of its NO_x and 97 percent of its SO_x, due to high emission rates shown in **Figure 35**. Coal plants also produce other pollutants, including primary particulate matter and mercury, the latter of which is associated with adverse neurological health outcomes, particularly for infants and children.[118] In addition, NO_x and SO_2 can oxidize in the atmosphere and react with other compounds to form secondary particulate matter and ground-level ozone. The health impacts of these pollutants are typically highest per capita near the plants but their impacts can stretch for hundreds of kilometers downwind.[119] The most polluting of Nevada's coal plants — North Valmy — is already slated to retire by 2025, and Nevada Gold Mines, the operator of the other facility, plans to convert the TS Power Plant to natural gas by 2022, although it will still be able to burn coal if needed.[120] Although it does not contain any coal plants, the Las Vegas region, which is considered out of attainment for federal ozone standards, is still home to numerous natural gas plants, which produce ground-level ozone precursors such as NO_x, VOCs, and unburned methane.

118 US Environmental Protection Agency. "Health Effects of Exposure to Mercury." Accessed Nov. 2020. Available at: https://www.epa.gov/mercury/health-effects-exposures-mercury

119 Levy, Jonathan I., *et al*. Uncertainty and Variability in Health-Related Damages from Coal-Fired Power Plants in the United States. *Risk Analysis: An International Journal* 29.7 (2009): 1000-1014.

120 Harding, Adella. NGM Converting Power Plant to Reduce Carbon Emissions. *Elko Daily,* June 3, 2020.

FIGURE 35. Power plant emission rates of CO_2, NO_x, and SO_2 in 2019. Bubble size reflects the total electricity generated by that plant in 2019. Date labels indicate plants with planned retirement dates. Some plants show much higher emission rates than others for every megawatt-hour (MWh) of electricity generated; the plant with the highest rates retired in 2019.



As noted in the Background section, health impacts are not limited to the populations closest to power plants, but living near power plants is associated with increased rates of adverse health outcomes.[121,122] We therefore analyzed the demographics of populations living within a three-mile radius of Nevada's power plants, which is the distance used by the US Environmental Protection Agency to analyze populations living near power plants.[123] In **Figure 36**, we plot power plants by the racial and low-income demographics of those living within a three-mile radius. Half of the state's plants aren't shown, since few or often zero people live within three miles of these facilities, including both coal plants. Notably, those plants that are in urban areas are largely within communities with a higher share of low-income households and populations of color than Nevada at large.

Rapid decarbonization of Nevada's power sector is central to achieving the state's 2030 climate goals. In the Core decarbonization pathway (see **Table 2**), coal electricity generation is entirely phased out by 2025. Renewable electricity generation supplies nearly 75 percent of in-state electricity by 2030, with the remainder from other sources, including natural gas. However, even in 2050, the Core scenario assumes natural gas is combusted at a number of facilities for reliability purposes—in contrast to the Fossil Free scenario, where this gas is replaced with carbon-neutral fuels. The transition to renewable energy yields two primary opportunities for environmental and social equity benefits: reduction of total health damaging air pollutants from power plants, and the prioritized retirement of facilities in pollution-overburdened communities. However, the realization of these benefits depends on the transition pathway itself.

The modeled decarbonization pathways prioritize the retirement of coal plants, but all leave thermal capacity in place and burn either natural gas, synthetic fuels, biofuels, or hydrogen. While these plants are expected to operate infrequently to help meet peak demand—total NO_x emissions fall 87 percent in the Core scenario between 2020 and 2030—they will continue to generate some electricity, and therefore may still produce NO_x emissions, particularly to meet cooling loads on hot summer days when ground-level ozone is already high. Without clear policy directives to help determine which plants are being used for these reliability needs, the state runs a risk of leaving gas plants disproportionately in urban, pollution-overburdened communities, particularly in the Las Vegas area, shown in **Figure 37**.

Current energy storage technologies may be able to replace some of these gas plants in the near term, such as the Sun Peak Generating Station in Las Vegas, which is used to meet peak demand. Even in the Fossil Free scenario, the type of carbon-neutral fuel replacing natural gas in power plants may affect the associated health risks. For example, the combustion of hydrogen produces water as a by-product, but the combustion of biogas can still produce criteria air pollutants.[124] In the long term, emerging long-duration energy storage technologies may be able to fully replace combustion-based power plants and eliminate these concerns.[125]

121 Ha, Sandie, *et al*. Associations Between Residential Proximity to Power Plants and Adverse Birth Outcomes. *American Journal of Epidemiology* 182.3 (2015): 215-224.

122 Casey, Joan A., *et al*. Retirements of Coal and Oil Power Plants in California: Association with Reduced Preterm Birth Among Populations Nearby. *American Journal of Epidemiology* 187.8 (2018): 1586-1594.

123 EPA, "EJ Screening Report for the Clean Power Plan," US Environmental Protection Agency, Tech. Rep. Docket: EPA–HQ–OAR–2013–0602, (2015).

124 Paolini, Valerio, *et al.* Environmental Impact of Biogas: A Short Review of Current Knowledge. *Journal of Environmental Science and Health, Part A* 53.10 (2018): 899-906.

125 Dowling, Jacqueline A., *et al.* Role of Long-Duration Energy Storage in Variable Renewable Electricity Systems. *Joule* 4.9 (2020): 1907-1928.

FIGURE 36. Income and racial demographics of populations living within a three-mile radius of Nevada power plants. The urban plants (those represented by larger bubbles) are disproportionately located in the state's low-income communities and communities of color. Approximately half of the state's plants are not shown because no one lives within a three-mile radius of these facilities.

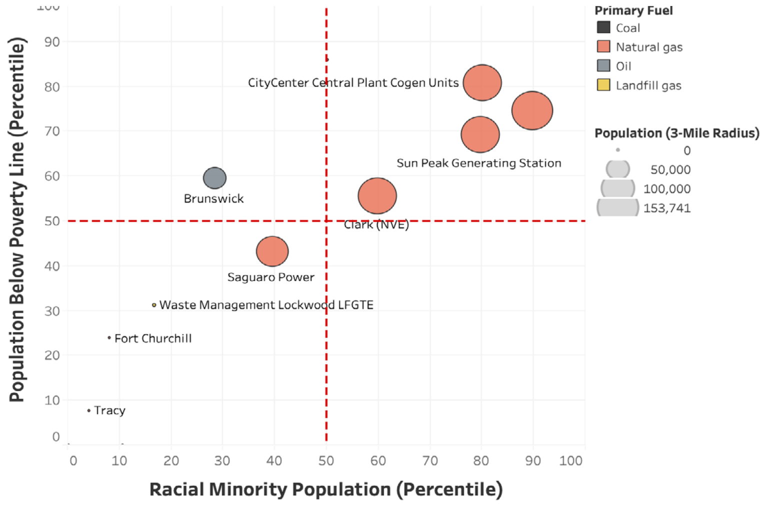
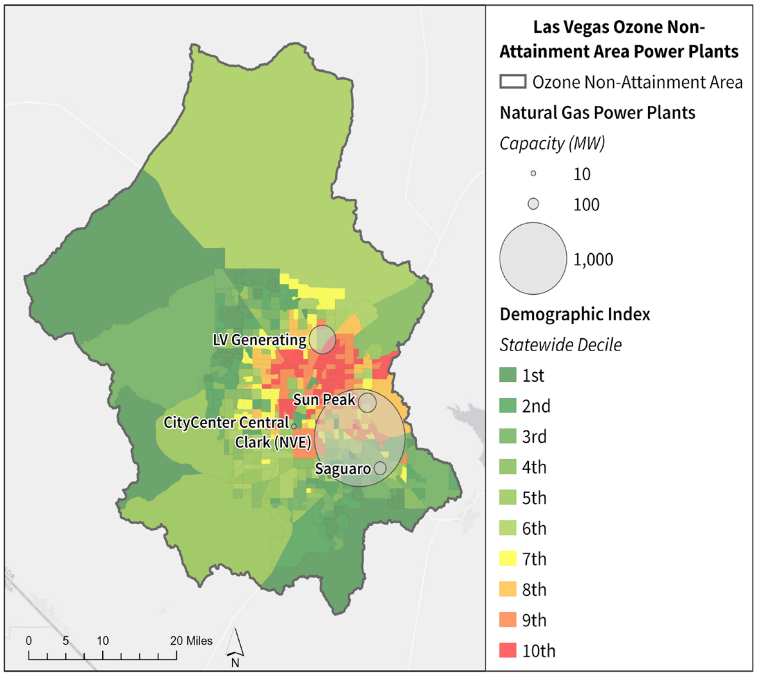
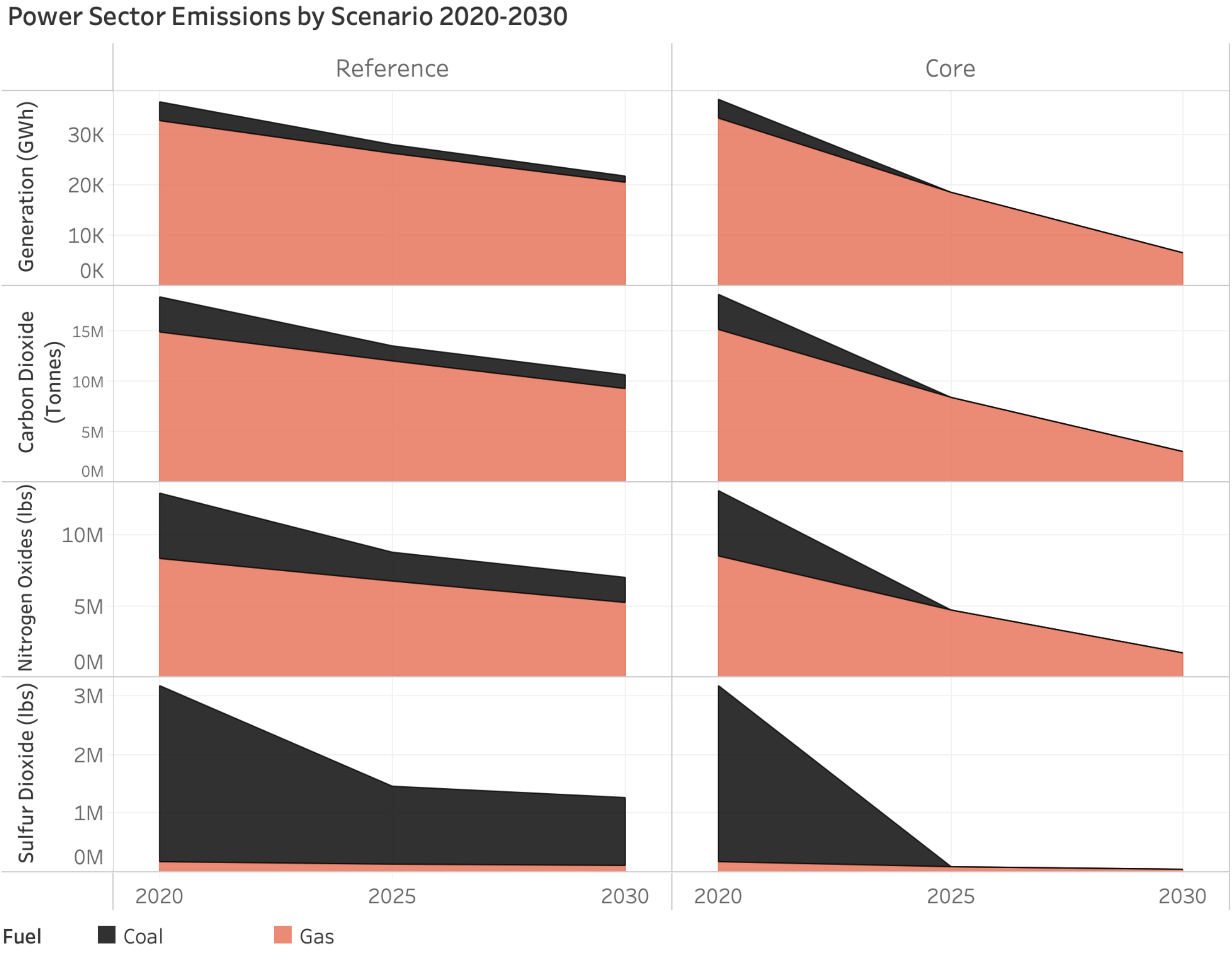


FIGURE 37. Map of natural gas plants in the Las Vegas ozone nonattainment region, with our Demographic Index. Several power plants in the ozone nonattainment region are in communities which score highly on our Demographic Index. Prioritizing their retirement presents opportunities to further environmental and social equity while improving regional air quality.



In **Figure 38** we show the electricity generation (MWh) and total emissions of CO_2, NO_x, and SO_2 for the Reference (business-as-usual) and Core decarbonization scenarios from 2020-2030. The Low Demand scenario looks similar to the Core scenario for the power sector during this time frame. In the Core scenario, coal emissions fall to zero in 2025 and natural gas emissions fall 87 percent by 2030. In the Reference scenario, however, coal generation declines only by half by 2030, leaving high levels of emissions of SO_2 and slightly increasing NO_x in 2030.

FIGURE 38. Electricity generation, CO_2, SO_2, and NO_x emissions from 2020-2030 for the Reference, and Core scenarios. The Low Demand scenario is similar to the Core scenario, while coal stays online in the Slow Coal Retirement scenario similar to the Reference scenario. SO_2 and NO_x emissions are only slightly lower than the Reference scenario in the Slow Coal Retirement scenario.



2.6 **Industrial Sector**

2.6.1 Overview

Nevada's industrial sector is responsible for a large share of criteria pollutant emissions across the state (see **Figure 1**), although not all of these are from fossil fuel combustion and therefore may not be mitigated through decarbonization measures such as electrification. Decarbonizing fuel use and improving energy efficiency in the industrial sector, which are incorporated into each of Evolved's modeled decarbonization scenarios, will reduce a portion of industrial criteria air pollutant emissions but will not eliminate them entirely. Non-combustion emissions, including fugitive emissions from oil and gas transmission and distribution and byproduct emissions from mining and industrial product manufacturing and consumption, may not be directly addressed by decarbonization measures.

Determining the extent to which criteria air pollutant emissions will be reduced through decarbonization is difficult due to limited emissions data across Nevada's industrial sector. While data are available on carbon emissions from fossil fuel use across industrial subsectors, facility-level data on criteria pollutant emissions from industrial point sources do not adequately distinguish between combustion and non-combustion emissions. Without this attribution, we cannot reasonably estimate what fraction of criteria air pollutant emissions from industrial point sources will be reduced through decarbonization measures, which primarily address combustion processes through electrification, energy efficiency, and the replacement of fossil fuels with biofuels and synthetic fuels.

Additionally, distributed emissions from industrial nonpoint sources across the state—including emissions from industrial fuel combustion—are only available at the county level. Without sufficient spatial granularity, we cannot thoroughly assess the environmental equity and health impacts of these distributed sources. Given the lack of facility-level data on criteria air pollutant emissions from fuel combustion and spatially granular emissions data for distributed sources, we can only describe potential health and environmental equity implications of industrial decarbonization in broad strokes.

2.6.2 Industrial Point Source Emissions

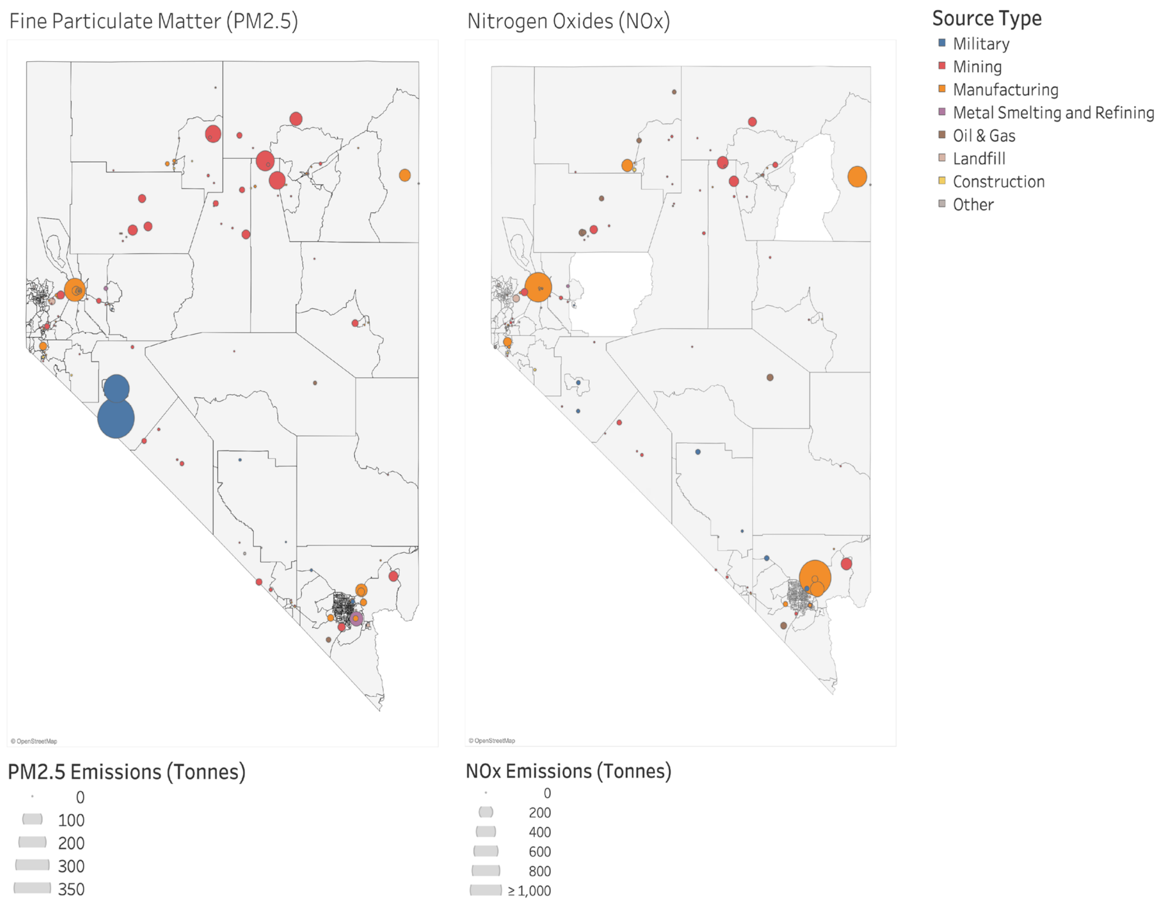
The mining industry, Nevada's largest export industry, includes metal mining for gold, silver, and copper as well as non-metallic mining for minerals such as lithium, iron, molybdenum, gypsum, limestone, sand, and gravel.[126] Mining contributes a significant portion of industrial $PM_{2.5}$ emissions, although not all of these emissions are from fossil fuel combustion (**Figure 39**). Military facilities in Hawthorne are also high-emitting point sources of $PM_{2.5}$, while manufacturing facilities are the largest sources of industrial NO_x (**Figure 39**).

As mining consumes the most energy of Nevada's industrial sectors (**Figure 40**), decarbonizing fuel use at metal and non-metallic mining facilities will be critical to reducing energy-related criteria air pollutant emissions in Nevada. The majority of energy currently used in the mining industry in Nevada is electricity (58 percent), which will become less emissions-intensive as the power sector decarbonizes. While electricity is projected to make up an increasing fraction of fuel use at mining facilities from 2017-2050 in the Core scenario, growing from 58 percent to 73 percent, fossil fuel use is projected to persist despite decarbonization. Fossil fuel use is projected to make up roughly 27 percent of fuel use at mining facilities in 2050 (**Figure 41**), which will likely result in lingering criteria air pollutant emissions at these facilities. Implementing energy efficiency measures to reduce industrial fuel use and replacing fossil fuel combustion with electricity and hydrogen will be needed to eliminate energy-related criteria air pollutant emissions at mining facilities throughout the state. Non-energy related criteria air pollutant emissions, while outside the scope of this report, may have important implications for environmental equity and public health and will need to be addressed through pollution control measures alongside Nevada's decarbonization efforts.

126 Nevada Governor's Office of Economic Development. "Mining." Accessed: Dec. 2020. Available at: https://goed.nv.gov/key-industries/mining/.

Though most of Nevada's mining industry is presently centered around precious metals such as gold and silver, the United States' known lithium reserves rank fifth in the world, and Nevada's reserves are among the largest in the country.[127,128] An important component of many emerging clean energy technologies, lithium demand is projected to grow as economies increasingly rely on low-carbon technologies such as electric vehicles and battery storage.[129] This provides Nevada a timely economic opportunity as the state and the nation build out their clean energy economies. Importantly, State policymakers and regulators also have a timely opportunity to assure that the clean energy economy is as beneficial and minimally harmful as possible by facilitating job transitions for metal mining workers, protecting nearby communities from pollution, and protecting vulnerable species. Failure to build out the clean energy economy carefully may undercut some of these technologies' environmental and social benefits. These points are further illustrated in **Section 2.7.3**, which provides an in-depth look at existing and proposed lithium mining operations in Nevada.

FIGURE 39. 2017 $PM_{2.5}$ and NO_x emissions from industrial point sources in Nevada. Mining facilities along Interstate 80 and military facilities in Hawthorne are the largest contributors to industrial $PM_{2.5}$ point source emissions statewide. Lime, gypsum, and cement manufacturing are the largest point sources of industrial NO_x emissions. Manufacturing and metal refining facilities are significant sources of NO_x and $PM_{2.5}$ in close proximity to the urban centers of Reno and Las Vegas.



127 US Geological Survey. Mineral Commodity Summaries: Lithium (2020).

128 Karl, N.A., *et al.* Lithium Deposits in the United States: U.S. Geological Survey Data Release, (2019).

US Geological Survey.

129 Peiro, Laura Talens, *et al.* Lithium: Sources, Production, Uses, and Recovery Outlook. *Journal of the Minerals, Metals & Materials Society,* 65.8 (2013): 986-996.

FIGURE 40. Fuel consumption by industrial subsector in Nevada, 2017-2050. Mining facilities consume the most fuel of Nevada's industrial subsectors, accounting for 65 percent of total industrial fuel use in 2017 and over 50 percent in 2050 in the Core scenario. Implementing energy efficiency measures and decarbonizing fuel use at these facilities will be critical to reducing energy-related criteria air pollutant emissions from the industrial sector in Nevada.

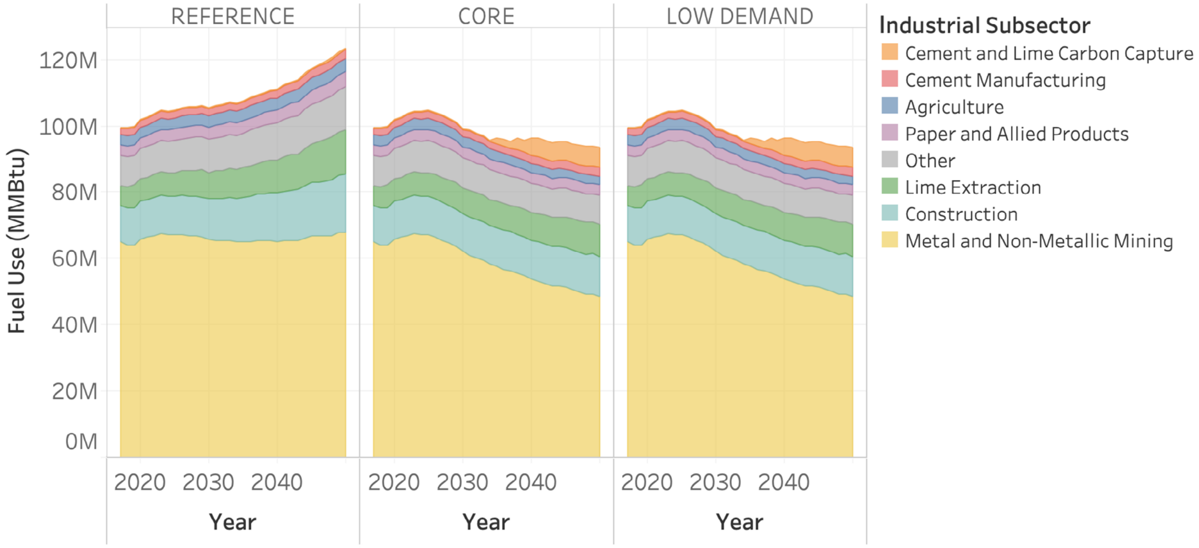
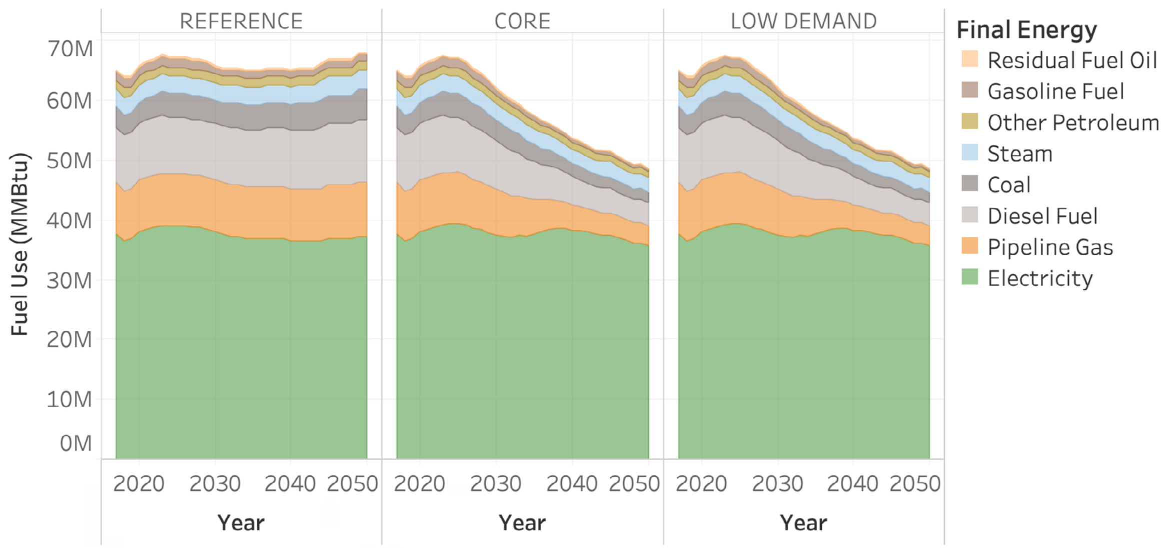


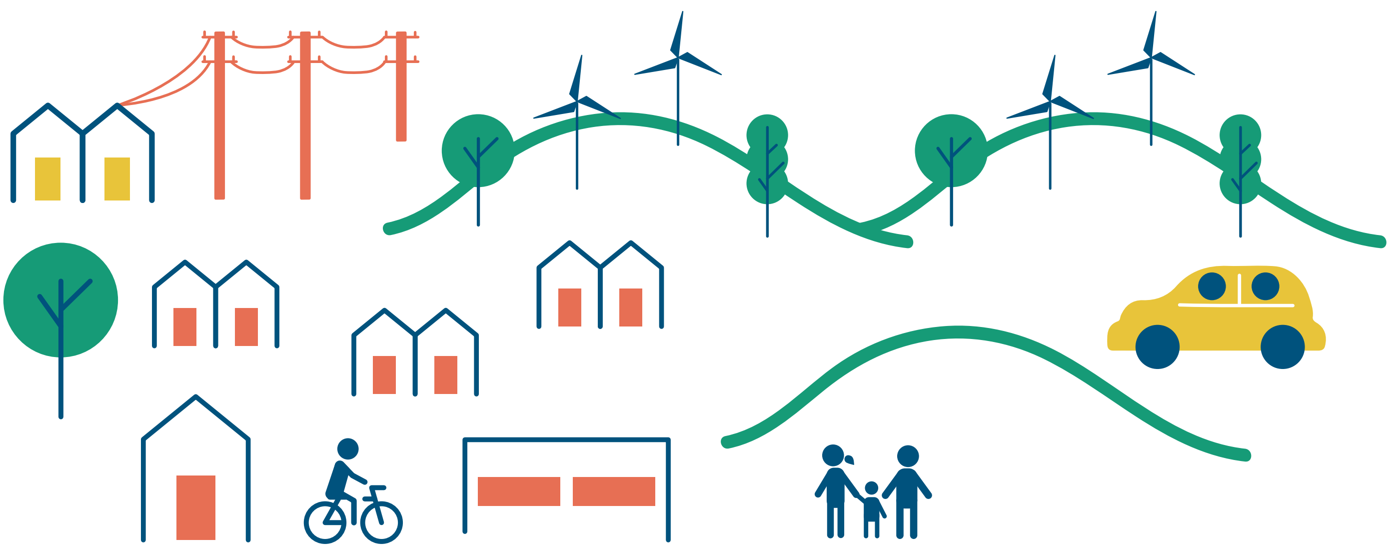
FIGURE 41. Nevada mining industry fuel consumption by fuel type, 2017-2050. Electricity is projected to make up an increasing fraction of fuel use at mining facilities from 2017-2050 in the Core scenario (growing from 58 percent to 73 percent), and will become less emissions-intensive as the power sector decarbonizes. Continued use of fossil fuels in 2050, however, will likely result in lingering criteria air pollutant emissions at these facilities.



2.6.3 Oil and Gas Transmission and Distribution

As Nevada has no significant crude oil or natural gas reserves, oil and gas production in the state is limited.[130] Greenhouse gas emissions from the oil and gas sector in Nevada, which make up roughly one-sixth of industrial greenhouse gas emissions in the state,[131] are primarily from transmission and distribution facilities such as pipelines and compressor stations, rather than production facilities.[132] Eliminating leaks from the transmission and distribution infrastructure would reduce emissions of health-damaging non-methane VOCs, as well as methane, an ozone precursor and potent greenhouse gas with 84- to 87-times[133] the global warming potential of CO_2 over a 20-year time period.

While oil and gas development in Nevada has historically been minimal compared to other states, federal land leases for oil and gas exploration in the state have increased significantly in recent years, with 1.8 million acres of federal lands auctioned for lease since March 2017.[134] Rather than open up additional land to potential oil and gas development, Nevada can minimize greenhouse gas emissions and health-damaging air pollution by phasing out in-state oil and gas production entirely, minimizing leaks and fugitive emissions from the transmission and distribution infrastructure, and transitioning the energy economy to maximize use of the state's wealth of renewable resources.[135]



130 US Energy Information Administration. "Nevada: State Profile and Energy Estimates" (2020). Accessed: Nov. 2020. Available at: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_prices/res/pr_res_NV.html&sid=NV.

131 Nevada Division of Environmental Protection. Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 1990-2039. *State of Nevada* (2019).

132 *Ibid.*

133 US Environmental Protection Agency. "Greenhouse Gas Emissions: Understanding Global Warming Potentials." Accessed: Nov. 2020. Available at: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.

134 Magill, Bobby. Nevada Becoming Wild West for Oil Speculation. *Bloomberg Law*. Aug. 5, 2019.

135 US Energy Information Administration. "Nevada: State Profile and Energy Estimates" (2020). Accessed: Nov. 2020. Available at: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_prices/res/pr_res_NV.html&sid=NV.

2.7 Cross-Sectoral Themes

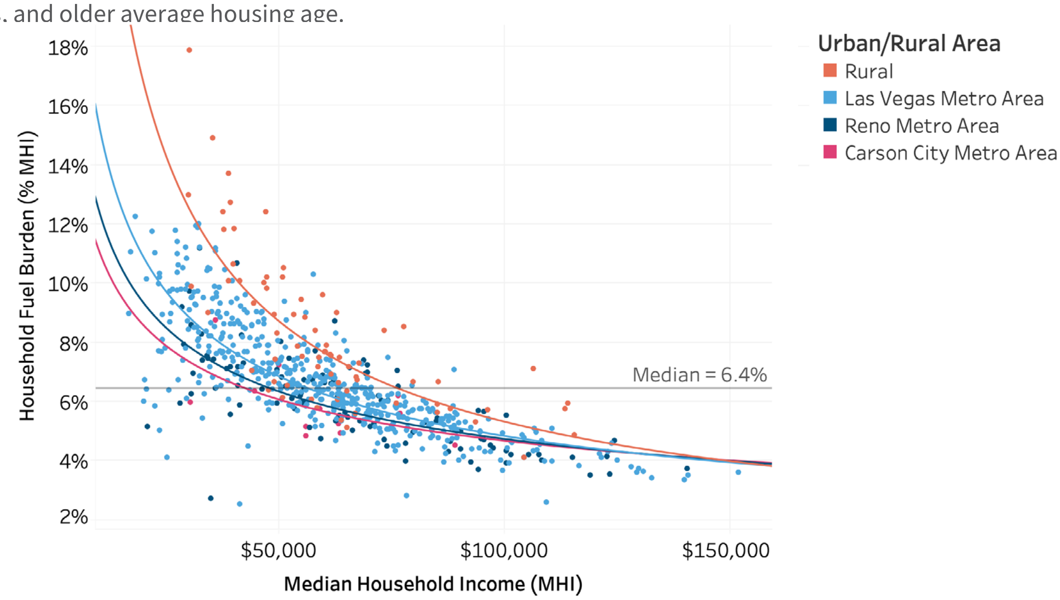
In the previous sections, we analyze existing pollution, energy cost burdens, and decarbonization pathways on a sectoral basis. Below, we address the intersection of these sectors: combined energy cost, environmental, and socioeconomic burdens, opportunities to reduce cumulative pollution from multiple sources, and the trade-offs between each pathway that result from prioritizing decarbonization in some sectors before others.

2.7.1 Combined Energy Cost Burdens

While household CO_2 emissions tend to be higher for census tracts with higher median incomes, energy cost burdens are highest for households in census tracts with the lowest median incomes. These energy bills are even more burdensome when considered in combination across sectors. **Figure 42** shows combined utility bill and vehicle fuel burdens for average households in each census tract as compared to median household income. While the median combined household energy cost burden is 6.4 percent of household income, some census tracts have combined average energy cost burdens as high as 18 percent, and these values do not reflect additional spending on public transit nor vehicle maintenance.

On average, rural households face higher energy cost burdens than urban households, in part due to longer driving distances, lower average incomes, older housing stock, and more expensive residential heating fuels.[136] Additionally, census tracts within tribal lands had higher average combined fuel burdens; and we found that census tracts with at least 25 percent of their population living in tribal lands had a median combined fuel burden of 11 percent, compared to the statewide median of six percent. Individual households within each census tract, of course, may spend an even greater fraction of their annual income on transportation fuel, heating their homes, and powering their appliances.

FIGURE 42. Average combined residential energy and vehicle fuel cost burden and median household income by census tract. On average, low-income households spend a greater fraction of their annual income on residential heating, household appliances, and vehicle fuel. Rural households[137] tend to have higher combined energy cost burdens than urban households, in part due to longer average driving distances, lower average household incomes, more expensive residential fuels, and older average housing age.



136 US Energy Information Administration. "Nevada: State Profile and Energy Estimates, Table ET3. Residential Sector Energy Price and Expenditure Estimates, 1970-2018, Nevada." Accessed: Oct. 2020. Available at: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_prices/res/pr_res_NV.html&sid=NV

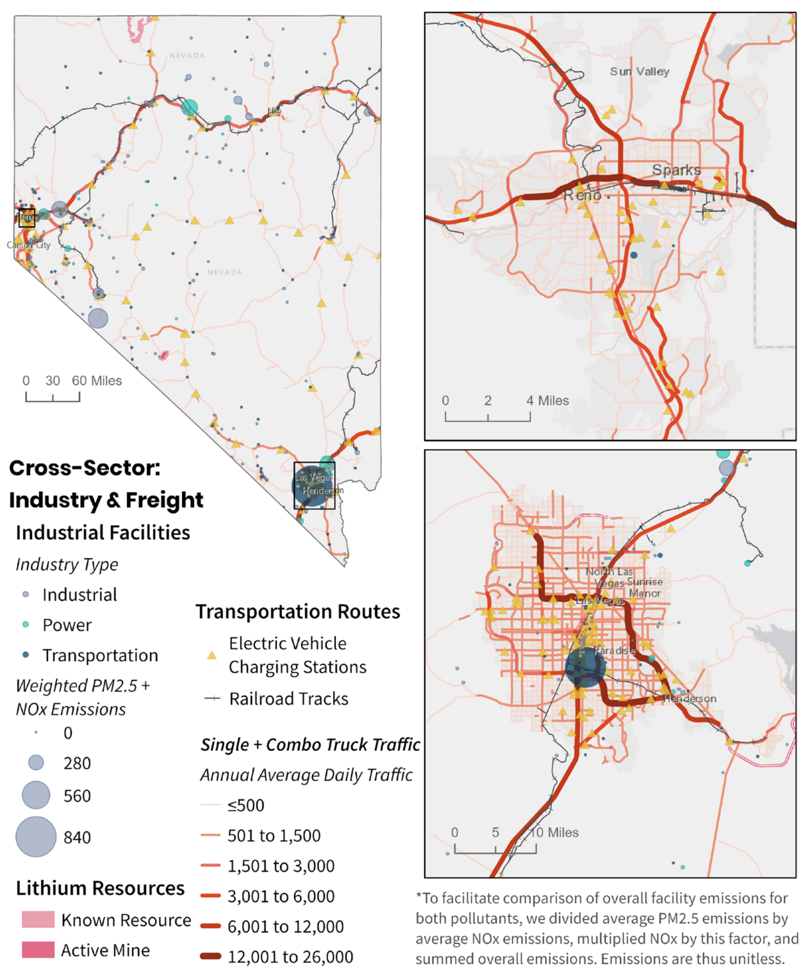
137 Rural areas refer to all census tracts that are not designated as metropolitan statistical areas by the US Census Bureau. This includes micropolitan statistical areas (at least one urban cluster of at least 10,000 but less than 50,000 population), as well as census tracts that are neither metropolitan or micropolitan.

2.7.2 Cumulative Cross-Sector Emissions

Cumulative emissions across sectors can contribute to both regional air pollution—such as high ozone levels across Las Vegas—and localized pollution hotspots. **Figure 4** illustrates cumulative NO_x emissions across the state, which are most highly concentrated in Nevada's ozone nonattainment area and in the Reno area. Decarbonization, as we have seen, can help eliminate some emissions, but may not do so evenly. Most of the decarbonization scenarios—with the exception of Slow Coal Retirement—eliminate the majority of power sector emissions by 2030. Fossil fuel combustion in residential and commercial buildings is of particular concern in terms of indoor air pollution, but apart from emissions related to wood burning, building-related emissions are projected to substantially decrease with decarbonization efforts, and are less likely to be major contributors to cumulative cross-sector emissions. Instead, based on our findings, the two sectors likely to have the highest combined emissions in many locations in the coming years are transportation and industry.

In **Figure 43**, we show truck traffic, as well as industrial, power, and transportation-related point sources in Nevada. These maps suggest neighborhoods where cross-sectoral pollution reduction strategies, such as electrification of trucks serving industrial facilities, may be particularly valuable.

FIGURE 43. Industrial and Transportation Hotspots. Many of Nevada's highest emitting industrial facilities sit along major trucking routes. Assuring that electric vehicle charging stations along these routes are suitable for trucks and incentivizing fleet electrification for industrial facilities may be useful for reducing cumulative environmental burdens along these routes.



*To facilitate comparison of overall facility emissions for both pollutants, we divided average PM2.5 emissions by average NOx emissions, multiplied NOx by this factor, and summed overall emissions. Emissions are thus unitless.

There is a positive correlation between racial minority population fraction and baseline cross-sectoral NO_x and $PM_{2.5}$ emissions density in urban neighborhoods. In addition to reducing emissions through decarbonization measures, other initiatives such as urban greening have the potential to reduce pollution and bring other public health benefits to these areas. A recent investigation from National Public Radio found that out of the 97 most populous cities in the US, North Las Vegas and Las Vegas were both among the ten cities with the strongest inverse correlation between median household income and surface temperature at the census tract level.[138] Disparities in green cover, green spaces, and trees, among other factors, have been found to contribute to the variation in surface temperature within cities.[139] In addition to mitigating the urban heat island effect, green vegetation can play a valuable role in removing pollutants such as ozone and particulate matter from urban environments,[140] and have been associated with improved mental and physical health outcomes. Unfortunately, there is a lack of high-density air monitoring to capture neighborhood-to-neighborhood variations in atmospheric pollutant concentrations. Neighborhoods with high cumulative emissions and high surface temperatures, including those parts of the historically segregated Historic Westside adjacent to major roadways in Las Vegas,[141] may benefit from a set of cross-sectoral intervention policies, from subsidized tree planting to the re-routing of heavy-duty trucks away from these areas. High-density air monitoring at the community level could also help guide and evaluate the effectiveness of such policies.

2.7.3 Materials Extraction and Renewable Energy Production

As economies decarbonize, demand for the materials underlying low-carbon technologies is rapidly increasing. Global lithium production is projected to grow substantially by 2100—largely to meet increased demand for batteries,[142] particularly electric vehicle batteries.[143] Most of the world's lithium reserves are in the Andean region,[144] where resource extraction has resulted in increased investment as well as social and environmental challenges such as exploitation of Indigenous communities and exacerbation of water shortages and biodiversity loss.[145] The United States has historically imported most of its lithium from this region and other countries, though there is strong interest in building out the domestic lithium industry.[146] With its substantial reserves and downstream infrastructure such as electric vehicle plants, Nevada will be critical to these efforts. Accordingly, the State is well-positioned to assure the industry is built out in a way that equitably maximizes social and economic benefits while minimizing environmental harm.

The Silver Peak mine in Esmeralda County is the only active lithium mine in the United States.[147] Saline groundwater is left to evaporate in a lined ditch, leaving behind a concentrated solution which is subsequently processed to isolate lithium. Two proposed mines, which are among the farthest along in planning, would use a different approach. The nearby Rhyolite Ridge project

138 Anderson, Meg and Sean McMinn. As Rising Heat Bakes U.S. Cities, The Poor Often Feel It Most. *National Public Radio*. September 3, 2019.

139 Plumer, Brad and Nadja Popvich. How Decades of Racist Housing Policy Left Neighborhoods Sweltering. *The New York Times,* Aug. 24, 2020.

140 Nowak, David J., Daniel E. Crane, and Jack C. Stevens. Air Pollution Removal by Urban Trees and Shrubs in the United States. *Urban Forestry & Urban Greening* 4.3-4 (2006): 115-123.

141 Anderson, Meg and Sean McMinn (2019).

142 Ambrose, Hanjiro, and Alissa Kendall. Understanding the Future of Lithium: Part 1, Resource Model. *Journal of Industrial Ecology* 24.1 (2019): 80-89.

143 Kavanagh *et al.* Global Lithium Sources—Industrial use and Future in the Electric Vehicle Industry: A Review. *Resources* 7.3 (2018): 57.

144 United States Geological Survey. "Lithium Data Sheet - Mineral Commodity Summaries 2020." Accessed Dec. 2020. Available at: https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-lithium.pdf

145 Romero *et al.* Mining Development and Environmental Injustice in the Atacama Desert of Northern Chile. *Environmental Justice* 5.2 (2012): 70-76.

146 United States Geological Survey. "Interior Releases 2018's FInal list of 35 Minerals Deemed Critical to U.S. National Security and the Economy." May 2018. Accessed Dec. 2020. Available at: https://www.usgs.gov/news/interior-releases-2018-s-final-list-35-minerals-deemed-critical-us-national-security-and

147 United States Geological Survey. "Lithium Data Sheet." 2020. Accessed Dec. 2020. Available at: https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-lithium.pdf

and the Thacker Pass project of Humboldt County would use an open pit mining approach and leach lithium out of clay with sulfuric acid. Apart from these projects, lithium exploration claims across Nevada have increased rapidly in recent years, with 8,000 claims as of 2020.[148]

Impacts on water quality and availability have been identified as issues of concern in global lithium mining contexts,[149] though are currently understudied.[150] In Nevada, potential water resource impacts have also been identified. These issues include water quality and availability, with the potential for some surface waters fed by groundwater to dry up due to decreased flow and some contaminant levels to potentially exceed Nevada's public health-based drinking water standards due to contact with pollutants in the mine's open pit.[151] Though neighboring communities have historically been provided greater opportunity to raise these and other issues during Federal environmental review, this process has been reduced in duration and substance by an executive order requiring a one-year timeframe and establishing strict page limits,[152] limiting the public's ability to meaningfully engage in the planning process and thoroughly understand studies' findings. It is therefore important for the State to provide ample opportunity for active community participation in planning and decision making, as well as for the State to require thorough environmental permitting and monitoring processes.

Similar to other means of energy production, such as fossil fuel extraction,[153,154] mining is associated with species impacts,[155] and extracting the raw materials for renewable technology may exacerbate mining-related biodiversity loss.[156] For example, the rare endemic plant Thiem's buckwheat is expected to decline by 50 to 70 percent should the Rhyolite Ridge mine proceed as proposed,[157] which conservationists worry could mean the species' extinction.[158] The mining company is funding studies to see if the plant can be transplanted, though findings may not be conclusive for years.[159] Similarly, many lithium mining claims in the Railroad Valley overlap with critical habitat for the Railroad Valley springfish,[160] an endemic fish with a limited range and cultural significance as a traditional food source for the Shoshone people.[161]

Like lithium mining, utility-scale solar development presents Nevada an opportunity to play an important role in the growing low-carbon economy, though

148 Nevada Division of Minerals Open Data Site. "Inferred Nevada Lithium Placer Claim Listings." Accessed Nov. 2020. Available at: https://data-ndom.opendata.arcgis.com/pages/lithium-claims

149 Liu, Wenjuan *et al.* "Spatiotemporal Patterns of Lithium Mining and Environmental Degradation in the Atacama Salt Flat, Chile." International Journal of Applied Earth Observation and Geoinformation. Aug. 2019.

150 Flexer, Victoria *et al.* "Lithium Recovery from Brines: A Vital Raw Material for Green Energies with a Potential Environmental Impact in its Mining and Processing." Science of the Total Environment. 2018.

151 U.S. Bureau of Land Management and Lithium Nevada Corporation. "Thacker Pass Draft Environmental Impact Statement."July 2020. Accessed Dec. 2020. Available at: https://eplanning.blm.gov/eplanning-ui/project/1503166/570

152 Office of the President. "Executive Order 13807: Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects." Federal Register(82:163). Aug. 2017. Accessed Dec. 2020. Available at: https://www.govinfo.gov/content/pkg/FR-2017-08-24/pdf/2017-18134.pdf

153 Copeland, Holly, *et al.* Mapping Oil and Gas Development Potential in the US Intermountain West and Estimating Impacts to Species. *PloS one* 4.10 (2009): e7400.

154 Jones, Nathan, *et al.* The Energy Footprint: How Oil, Natural Gas, and Wind Energy Affect Land for Biodiversity and the Flow of Ecosystem Services." BioScience(65:3). Mar. 2015.

155 Sonter et al. "Mining and Biodiversity: Key Issues and Research Needs in Conservation Science." *Proceedings of the Royal Society B* 285.1892 (2018): 20181926.

156 Sonter *et al.* "Renewable Energy Production Will Exacerbate Mining Threats to Biodiversity." *Nature Communications* 11.1 (2020): 1-6.

157 NatureServe Explorer. "*Erigonum Tiehmii*." Accessed Nov. 2020. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.151598/Eriogonum_tiehmii

158 *Ibid,*

159 Sonner, Scott. "AP Exclusive: Rare Wildflower Could Jeopardize Lithium Mine." *Associated Press.* Aug. 2020. Available at: https://apnews.com/article/ap-top-news-deserts-technology-reno-business-3ab59bbc4fd6e6c602b4b6d037ec7f12

160 U.S. Fish and Wildlife Service. "Environmental Conservation Online System." Accessed Dec. 2020. Available at: https://ecos.fws.gov/ecp/species/302#crithab

161 Goodeid Working Group. "*Crenichthys nevadae.*" Accessed Dec. 2020. Available at: http://www.goodeidworkinggroup.com/crenichthys-nevadae

this industry may also impact ecological and human health. Air quality and water quality impacts, including increased $PM_{2.5}$ emissions, have previously been noted.[162] Furthermore, studies in the Mojave have found that solar development resulted in diminished conservation value.[163] Mechanisms for flora and fauna species impacts include direct habitat destruction and fragmentation as well as indirect microclimate alteration, increased disturbance, and other means.[164] Requiring responsible siting which preferentially avoids valuable habitat and effective design which minimizes human health impacts can help utility-scale solar provide the greatest net benefit possible to Nevadans.

Despite these and other environmental constraints, these energy resources can play a key role in reducing carbon emissions with proper management, planning, and regulation. State oversight of mine- and utility-funded environmental studies and monitoring efforts may help assure scientific integrity and facilitate collection of the sound data needed to address trade-offs between energy needs and environmental protection. Additionally, proactively enacting state-specific protections for threatened species, ground and surface water, and other environmental resources of concern may incentivize siting and design which avoid environmental constraints, as well as providing accountability for impacts.

In Nevada, most known lithium resources are located near tribal communities and socioeconomically vulnerable neighborhoods, and many tribal and low-income communities in southern Nevada are located in areas with excellent solar potential (**Figure 42**). Mining operations and utility-scale solar development may therefore provide economic investment in communities which could benefit from well-paying jobs. However, similar operations have shown diminished economic benefits for local communities over time, due in part to increased portions of the workforce coming from outside of the community and the boom-and-bust nature of extractive industries.[165,166] Incentivizing local hire and requiring a living wage would be prudent to ensure the most impacted communities are also those most likely to benefit. Such measures would be most effective if economic diversification in mining communities is encouraged,[167] with the addition of jobs in related industries that do not directly rely on resource extraction providing better economic stability. Additionally, collaboration with the local community through such mechanisms as enforceable community development agreements[168,169] should be incentivized or required to maximize community benefits and engagement. Recent examples of successful community collaboration include utility-scale solar projects in partnership between tribal nations and private solar operators, which have generated lease revenues for the Tribe through use of their land for solar generation as well as creating job training and employment opportunities for tribal members.[170] Collaborative models like these may generate the most benefit for Nevadans as the State builds out its renewable energy sector.

162 Hernandez, Rebecca R., *et al.* Environmental Impacts of Utility-Scale Solar Energy. *Renewable and Sustainable Energy Reviews* 29 (2014): 766-779.

163 Parker, Sophie S., Brian S. Cohen, and James Moore. Impact of Solar and Wind Development on Conservation Values in the Mojave Desert." *PLoS One* 13.12 (2018): e0207678.

164 Lovich, Jeffrey E., and Joshua R. Ennen. "Wildlife Conservation and Solar Energy Development in the Desert Southwest, United States." *BioScience* 61.12 (2011): 982-992.

165 Liu, Wenjuan *et al.* Spatiotemporal Patterns of Lithium Mining and Environmental Degradation in the Atacama Salt Flat, Chile. *International Journal of Applied Earth Observation and Geoinformation* 80 (2019): 145-156.

166 Matheis, Mike. "Local Economic Impacts of Coal Mining in the United States 1870 to 1970." Cambridge University Press. Nov. 2016.

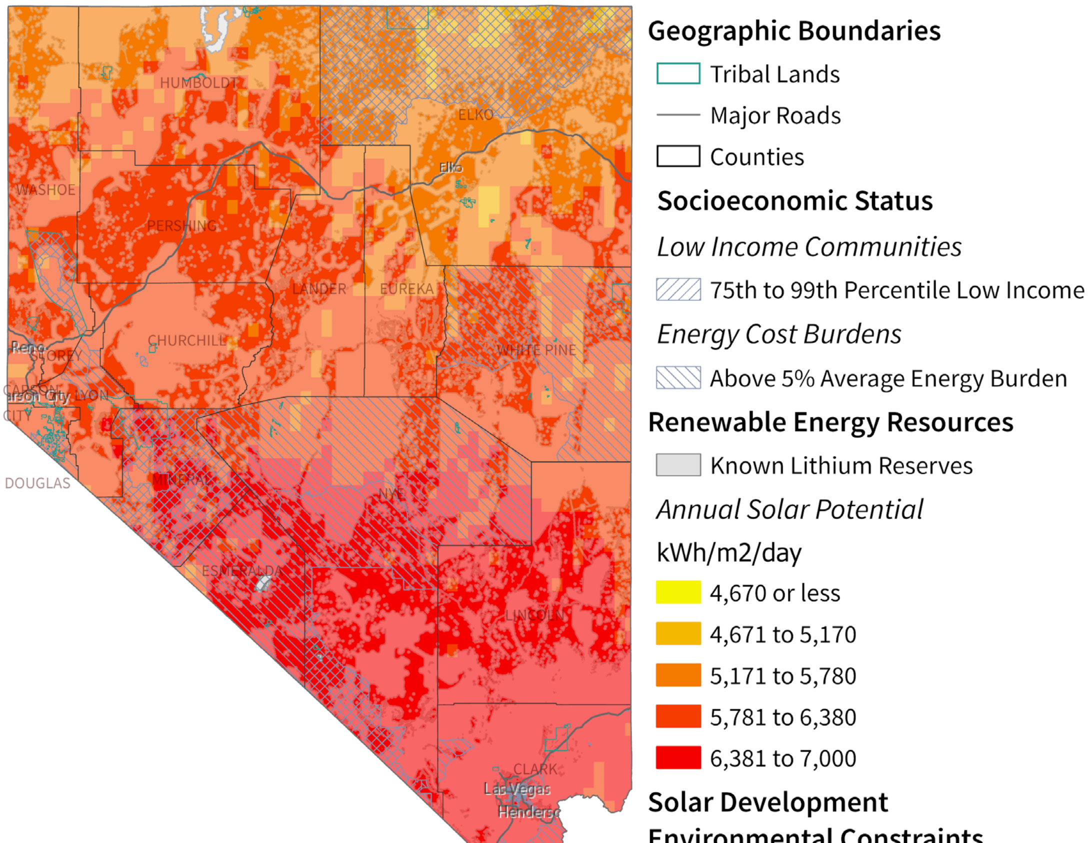
167 Stewart Lockie, *et al.* "Coal Mining and the Resource Community Cycle: A Longitudinal Assessment of the Social Impacts of the Coppabella Coal Mine." Environmental Impact Assessment Review (25:5). Sept. 2009.

168 Kristi D. Bruckner. "Community Development Agreements in Mining Projects." Denver Journal of International Law and Policy (44). 2015-2016.

169 Kendra E. Dupuy. "Community Development Requirements in Mining Laws." The Extractive Industries and Society(1:2). Nov. 2014.

170 Office of Indian Energy Policy and Programs. "Solar Project Provides Jobs and Training for Moapa Band of Paiute Indians." *US Department of Energy* (2016). Accessed: Dec. 2020. Available at: https://www.energy.gov/indianenergy/articles/solar-project-provides-jobs-and-training-moapa-band-paiute-indians

FIGURE 42. Renewable Potential, Economic Indicators, and Ecological Constraints. Nevada has excellent solar potential and some of the nation's largest known lithium reserves. The State has an opportunity to assure these industries are built out in a fashion which minimizes ecological impacts and maximizes economic benefits as Nevada and other states decarbonize.



Sources: US Census Bureau (geographic boundaries), United States Geological Survey (Known Lithium Reserves), National Renewable Energy Lab (Annual Solar Potential) The Nature Conservancy (High Conservation Value Lands)

2.7.4 Comparing Decarbonization Pathways

Along with clear climate benefits, all statewide decarbonization strategies explored in this report yield some similar air quality and human health co-benefits, such as overall reductions in criteria pollutant emissions. These findings are outlined in each section above. However, the underlying strategies in each decarbonization scenario also lead to certain unique outcomes. In Table 4, we summarize some of the unique impacts and benefits of each decarbonization pathway.

The trade-offs between scenarios tend to fall into two main categories: (1) impacts on bills and energy cost burdens, and (2) impacts on type and location of pollutant emission reductions. One of the pivotal decision-making points is regarding whether the Low Demand scenario is pursued. The Low Demand scenario has the greatest emissions reductions by 2030 and lowest utility bills, as well as increasing public transit and active transit options, which can particularly benefit low-income households and increase public health co-benefits. This scenario hinges on widespread efforts to increase building efficiency and build out public and active transportation. These actions require multi-agency coordination, significant municipal planning with community feedback mechanisms, and sufficient up-front capital expenditures, but yield longer term economic and environmental health benefits.

TABLE 4. Unique outcomes from each decarbonization scenario.

Scenario	Unique outcomes
Reference	• Energy demand is projected to increase with population growth across all sectors, along with greenhouse gas and health-damaging air pollutant emissions in most sectors.
Core	• Rapid greenhouse gas and criteria air pollutant emission reductions from the power sector, as well as sustained emission reductions in all other sectors. • Slight increase in residential criteria air pollutant emissions in some rural and mountain communities due to continued use of wood in home heating.
Slow Coal Retirement	• Significant persistent emissions from coal power plants through 2030, notably SO_2. • Higher average residential energy bills.
Low Demand	• Greatest near-term criteria air pollutant emission reductions. • Greatest particulate matter emission reductions from the transportation sector. • Increased access to public transit. • Greatest overall reduction in energy cost burdens. • Lowest overall utility energy bills.
Fossil Free	• Greatest long-term greenhouse gas and criteria air pollutant emission reductions across all sectors. • Opportunity to eliminate all fossil fuel infrastructure and associated health hazards. • Higher average residential energy bills (though these bills do not include the social benefits associated with greater reductions in carbon dioxide and criteria air pollutants).

3. **Policy Discussion**

Our analysis highlights the need to further integrate health, environment, and energy equity considerations into Nevada's deep decarbonization planning. A wide portfolio of policy options is available to support such a combined approach to achieving climate and energy equity goals. Below, we first briefly review the existing electricity market to understand the unique landscape. Next, we review a select number of existing climate and energy policies in Nevada from an environmental- and energy-equity lens. We then discuss the policy implications of our analysis for each sector in conjunction with those existing policies, or if none exist, where new ones might be valuable for consideration.[171] Finally, we describe additional data collection and research needs that can enable the state to create data-driven energy equity policies and measure their effectiveness moving forward.

3.1 **Electricity Market Landscape**

We begin with a brief overview of the current electricity market from a renewable energy and consumer protection perspective in order to provide context into how the current market operates, some of the key stakeholders involved in the market, and how consumers at large may navigate or experience the market. The present energy market landscape provides important context for many potential decarbonization initiatives due to utilities' role interfacing with businesses and residences, owning and operating much of the state's electric vehicle charging infrastructure, and sourcing energy from renewable and non-renewable sources, among other factors. The ability of regulators, policymakers, and consumers to use policy and market levers to decarbonize the state are therefore influenced by the existing energy market landscape.

In-state electric generation in Nevada is primarily fossil fuel-derived, with utility-scale solar and geothermal making up the majority of renewable generation.[172,173] Through the renewable portfolio standard, last legislatively updated in 2019 through SB 358 and made constitutionally required in 2020,[174] the State has set a target of reaching 50 percent renewables by 2030. Simultaneously, coal plants are retiring in accordance with 2013's SB 123,[175] which required all coal-fired power plants in Nevada to shut down. Electricity producers in the state include Rural Utility Service Areas (cooperatives owned by their members), and private utility and energy service providers.[176] NV Energy, the monopoly investor-owned utility holding company, controls generation, transmission, and retail, accounting for the majority of electricity in both northern (through regulated Nevada Power Company) and southern (through regulated Sierra Pacfic Power Company) Nevada. It is owned by Berkshire Hathaway Energy, and receives 70 percent of revenue from Nevada Power and 30 percent from Sierra Pacific.[177]

171 We offer two levels of suggestions in this section: **bolded** recommendations are our direct recommendations to the stakeholders involved and impacted by the State's decarbonization policies; they are standalone with supporting text. *Italicized* suggestions are found within the text and emphasize indirect recommendations we think are important to highlight, but that did not rise to the level of broader and more substantial bolded recommendations.

172 US Energy Information Administration. "Electricity Data Browser." Accessed Nov. 2020. Available at: www.eia.gov/electricity/data/browser/#/

173 Schub, Jeffery. Nevada Green Bank Study Deliverable 1 - Nevada Clean Energy Market & Policy Review. *Coalition for Green Capital*, (2016).

174 Question 6: Renewable Energy Standards Initiative was passed in 2018 and 2020 (two consecutive election cycles are required to amend Nevada's constitution), making the renewable portfolio standard of 50 percent renewable energy by 2030 constitutionally required. Through SB 358, the Standard is legislatively required.

175 Nevada 77th Legislative Session. Senate Bill 123 (2013).

176 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada*, (2019).

177 US Security and Exchange Commission. Registration for NV Energy, Inc. CIK #0000741508. Accessed Nov. 2020.

Some small areas of southern Nevada participate in other electric markets such as the Southwest and the California Independent System Operator (CAISO) markets and nearly all of Nevada participates in the Northwest market; these regional organizations under FERC are responsible for ensuring reliable power, transmission infrastructure, and wholesale market price stability.[178]

The electricity market in Nevada is not open, with little competition to lower electricity retail rates or to expand renewable energy and/or battery storage. The Energy Choice Initiative, a 2016 referendum to amend the Nevada state constitution, would have required the state legislature to eliminate NV Energy's monopoly and passed with more than 72 percent of votes.[179] This open-ended requirement left it to legislators to determine how to restructure the energy market, requiring any restructuring be more competitive and allow for free choice and assure consumer protection.[180] However, in the 2018 general election, the measure failed (67 percent voted no) after the monopoly utility, NV Energy, heavily opposed the measure.[181, 182, 183, 184]

Some larger industrial or commercial entities, such as MGM and Wynn, pay a multi-million dollar "impact fee" tariff to leave the NV Energy monopoly, but residential customers do not have that option available.[185,186] The tariff is supposed to be used to offset costs and financial damages incurred by Southern Nevada residential customers due to monopoly control;[187] however, due to lack of transparency, it is publicly unknown how those tariffs directly benefit residential ratepayers or if the funds are instead used to subsidize remaining business ratepayers. Therefore, NV Energy was ordered to start paying carrying charges, which can be used to help standardize and ensure these funds are directed to residential customers only, on all impact fees, to help increase greater accountability and transparency in fee beneficiaries.[188]

While residential customers cannot leave the NV Energy monopoly market, those that want to install and utilize solar or other renewable energy forms do have a "Bill of Rights" affirming net metering protections through 2017 AB 405.[189] In response to these measures, NV Energy created a Renewable Generations Systems Incentive Program to provide outreach and educational material to customers who want net metering for their private systems. Technologies eligible for incentives through the program include, but are not limited to, solar, electric vehicle charging infrastructure, and energy storage. In exchange, NV Energy receives renewable energy credits for these eligible net-metered systems, which are applied to the renewable portfolio standard for compliance.[190, 191] Additionally, Nevada's Solar Easement and Rights law protects the rights of those property and homeowners who wish to install solar energy on their property from unnecessarily restrictive contractual agreements, covenants, or prohibition by government at local levels.[192, 193]

178 Federal Energy Regulatory Commission. "Electric Power Markets: National Overview." Accessed Nov. 2020. Available at: www.ferc.gov/industries-data/market-assessments/electric-power-markets

179 Two election cycles of the same referendum are needed to amend the State constitution in Nevada.

180 Griffin, Matt, and Josh Weber. Energy Choice: A New Energy Policy for Nevada. *Energy Choice Initiative,* (2017).

181 *Ibid.*

182 Purtill, Corinne. Nevada's Question 3 Was a Fight Between Two Billionaires and Warren Buffett Won. *Quartz.* Nov 9, 2018.

183 National Association of State Energy Officials. Nevada Energy Markets and Planning Roadmap (2017).

184 Snyder, Riley. The Indy Explains: Everything You Need to Know about NV Energy's Solar Proposal. *The Nevada Independent*, June 17, 2018.

185 Purtill, Corinne. Nevada's Question 3 Was a Fight Between Two Billionaires and Warren Buffett Won. *Quartz.* Nov. 9, 2018.

186 Gheorghiu, Lulia. NV Energy Crafts Solar + Storage Subscription Plan to Keep Large Customers in Its Service. *Utility Dive*, May 12, 2020.

187 Nevada Public Utility Commission. Order Granting in Part and Denying in Part General Rate Application by Nevada Power Company, No. 17-06003, No. 17-06004. (2017).

188 *Ibid.*

189 Nevada 79th Legislative Session. Assembly Bill 405 (2017).

190 *Ibid.*

191 National Association of State Energy Officials, Nevada Energy Markets and Planning Roadmap (2017).

192 NV Rev Stat § 278.0208 (2011)

193 Governor's Office of Energy. "Renewable Energy System Determinations." Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Renewable_Energy_System_Determinations/

Triennially, the Nevada Public Utility Commission (PUC) reviews NV Energy's required operating costs and rate of return to shareholders, in a rate case review. The 2017 rate case review by the PUC for NV Energy set the rate of equity return to 9.7 percent, above which any additional profits earned would be equally shared between ratepayers and NV Energy. Feedback from ratepayer listening sessions helped shape the size of utility bill reductions and necessity of them for ratepayers, particularly for low-income Southern Nevada consumers. Additionally, the order reduced the fixed basic service charge by 25 cents per month, and also reduced volumetric charges (usage-based) on utility bills.[194] While shareholders received immediate and consistent benefit from this arrangement, NV Energy tracked and kept the ratepayers overearnings until their 2020 General Rate Case filing in June. To address this inequity and to assist ratepayers dealing with the financial impacts from the COVID-19 pandemic, the NV PUC required NV Energy to make a lump-sum, one-time credit to ratepayers, with set credits for single-family, multi-family, and small business customers (large customers receive credits based on individual usage). The October 2020 $120M rate reduction stemmed from lower expenditures (taxes and operating) and restructuring of debt, and a utility bill credit from over-earnings[195] and other financial accounting structuring.[196]

Nevada's focus on alleviating financial burdens for its electricity consumers while providing renewable energy and energy efficiency options has driven many legislative policies, regional compacts, and agency and local initiatives to be implemented. In the next section, we consider this existing policy framework as it relates to environmental and socioeconomic equity potential.

194 Nevada Public Utility Commission. Order Granting in Part and Denying in Part General Rate Application by Nevada Power Company, No. 17-06003, No. 17-06004. (2017).

195 Snyder, Riley. NV Energy Ordered to Pay Back $60 Million to Southern Nevada Customers After Over-Collection, About $53 per Household. *The Nevada Independent,* Sept.12, 2020.

196 Snyder, Riley. NV Energy Plan to Issue $120 Million Bill Credit, Lower Rates Approved by Utility Regulators. *The Nevada Independent*, Oct. 7, 2020.

3.2 **Existing Environmental and Energy Equity Policy Overview**

Below, we briefly review some of Nevada's existing and relevant policies to elucidate the broader landscape for policies at the intersection of climate justice and energy equity.[197] This review yields some initiatives that aim to address inequities across multiple sectors, with a variety of approaches. The state incorporates policy measures that reduce burdens to disproportionately impacted communities, specifically targeting low-income and senior populations. However, the enforcement components of these policies and further evaluation of other disproportionately-impacted communities—such as people of color, tribal nations, and those with limited educational attainment—are limited.

The National Association of State Energy Officials, US Department of Energy, and the Nevada Governor's Office of Energy partnered to create the 2018 Nevada Energy Markets and Planning Roadmap (E-MAP), which prioritizes 1) clean energy deployment, 2) creating a more resilient and cost-effective grid, and 3) promoting distributed energy resources (including rooftop solar and energy storage) and net metering by strategically planning in three key areas: distributed energy resources, renewable energy, and energy efficiency.[198]

The E-MAPs New Energy Industry Task Force conducted broad stakeholder outreach to develop the E-MAP policy recommendations in 2016, including meetings with representation from various stakeholders, such as industry, consumers, advocates, and regulators.[199] The E-MAP spurred several policy recommendations that can provide for more equitable outcomes for income-limited populations, including, but not limited to: 1) increasing energy storage, net and smart metering, and adjusting rate structures to encourage distributed energy resource development, 2) increasing access to renewable energy and accompanying required infrastructure through direct tax incentives, and 3) encouraging energy efficiency in residential and commercial sectors (e.g. creating the Performance Contract Audit Assistance Program to subsidize energy efficiency projects for undercapitalized existing building owners) to help reduce energy demand.[200] Even though the Governor's Office of Energy implemented many of these recommendations through programming, direct evaluation of how these programs impact various other demographic groups is incomplete, and we offer recommendations, as appropriate, in the upcoming section.

In 2017, SB 407 passed and created the Nevada Clean Energy Fund, a nonprofit created to expand clean energy projects and use to more commercial operations and residents, through 1) qualified project financing, 2) standardization for investment underwriting, and 3) creating and measuring performance data, which all lead to improved risk management and economy stimulation.[201] The goals of the Nevada Clean Energy Fund are to increase the speed and adoption of clean energy projects towards zero- or low-carbon generation to abate climate change, support energy efficiency measures, and raise the standard of living through an efficient project development application process, through financially subsidized deployment of clean energy projects.

The Nevada Clean Energy Fund's nine-member Board of Directors are governor-appointed, based on state, contractor, labor organization, and county commissioner affiliations. There is no representation required for appointment based on direct community input. The Board should have expertise in areas relevant to clean energy development, such as energy law and economics, and the governor must consider whether appointees

197 The State of Nevada has numerous policies related to environmental public health, climate change, and renewable energy, however, here we focus specifically on the intersection with energy equity and climate justice.

198 National Association of State Energy Officials. Nevada Energy Markets and Planning Roadmap (2017).

199 *Ibid.*

200 *Ibid.*

201 Nevada 79th Legislative Session. Assembly Bill 407 (2017).

reflect Nevada's geographic and ethnic diversity.[202] However, no other historically marginalized populations were explicitly required to be represented nor were considered for Board appointment.[203] Appointing a representative Board may help assure more equitable project prioritization, including prioritization of projects which are owned by, operated by, or otherwise directly benefit historically marginalized Nevadans. As the Clean Energy Fund can provide financial assistance to a variety of renewable energy projects, we recommend Board appointments by the governor should include populations with historically low homeownership rates, high energy cost burdens, and low clean energy and electric vehicle adoption rates. According to our analyses, these populations include, but are not limited to, people of color, low- and middle-income Nevadans, and renters.

2019's SB 254 requires the Department of Conservation and Natural Resources to publish and maintain a historic greenhouse gas inventory and create a 20-year statewide projection of emissions, including sector-specific emission estimates reported annually (for transportation and electricity production) or every four years (for industry, residential and commercial, agriculture, and land use). The bill acknowledges that through climate change, increased ambient temperatures and poor air quality during wildfires will adversely affect public health on "vulnerable populations" but does not directly provide actionable directives specifically focused on those "vulnerable populations" nor clearly indicates who is considered "vulnerable."[204]

From the first inventory report, published in 2019 with projections through 2039, fossil fuel-related emissions are predominantly in the energy sector, with the majority of emissions from transportation and electricity generation.[205, 206] This report also has numerous climate- and energy-focused recommendations that overlap with the recommendations from our study, by sector. However, one of the components missing in each of their sector-specific recommendations is how to address or reverse already existing disparities for marginalized communities, and how to prevent the exacerbation of greenhouse gases in those marginalized communities from continuing through the recommended actions. Their recommendation to "…equitably address carbon reduction…"[207] in the transportation sector may begin to address some equity concerns, but lacks specificity regarding which social equity barriers are being addressed and by what measurable metric.[208,209] Our findings further some of these, and additional, recommendations from a socioeconomic and demographic perspective.

Executive Order No. 2019-22, which furthered SB 254, required by December 1, 2020 a state-wide collaboration to create a State Climate Strategy that focuses on mitigating climate change and reducing greenhouse gas emissions through 1) sector-specific, market-based mechanisms to reduce overall greenhouse gas emissions, 2) funding and support for electrifying the transportation sector, 3) energy efficiency upgrades and retrofits for residential and commercial buildings, and 4) conservation efforts of natural resources to mitigate climate change-induced impacts.[210] Our findings can provide additional insight into the various ways the State Climate Strategy in Nevada can, and should, incorporate environmental and energy equity considerations, as we outline in the next section.

202 *Ibid.*

203 *Ibid.*

204 Nevada 80th Legislative Session. Senate Bill 254 (2019).

205 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada,*(2019**)**.

206 Nevada Division of Environmental Protection. Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 1990-2039. *State of Nevada* (2019)

207 *Ibid.*

208 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada*, (2019).

209 Nevada 80th Legislative Session. Senate Bill 254 (2019).

210 Governor Steve Sisolak. Executive Order 2019-22 (2019).

3.3 **Key Themes and Policy Implications by Sector**

Our findings across sectors reveal multiple opportunities for deep decarbonization in Nevada to simultaneously address environmental, socioeconomic, public health, and energy equity disparities. Building upon these key themes, we use our findings to inform and shape our policy recommendations through an energy and environmental equity lens, by sector and across sectors. We do not address the full scope of potential climate policies here, nor impacts—positive or negative—on the energy workforce, and instead focus on energy equity- and health-related climate policies.

Throughout all sectors evaluated in this study, a recurring and vital theme emerged that warrants action in every decision towards decarbonization; and that is the full engagement (i.e. representative and enforceable decision-making power) of the local and impacted community. Current legislative and regulatory processes could improve stakeholder participation through genuine, meaningful community engagement and participation, including but not limited to outreach during the design and planning stages of policy development and community feedback mechanisms that directly impact decision making and implementation. Improvements to community engagement should include:

1. Outreach to local residents and businesses near sources of high pollutant emissions, including:
   a. transportation hubs such as interstate corridors and bus yards,
   b. mining facilities, and
   c. other industrial point sources;
2. The provision of educational materials in local languages that explain how communities may benefit from (e.g. utility bill reductions, health improvement, etc.) and can access (e.g. how to apply for subsidies and financing) electrification and decarbonization measures;
3. Increased opportunities for binding community feedback as decarbonization efforts are developed, particularly in moderate- to low-income neighborhoods and communities of color; and
4. Community involvement in the ownership of decision-making processes through working groups or committees focused on how decarbonization efforts are rolled out, which communities should be prioritized, and how the benefits and costs of decarbonization should be allocated.[211]

211 These considerations also include workforce development, such as job retraining for workers in the fossil fuel industry, which will be addressed in a forthcoming partner report.

Nevada has a plethora of renewable energy- and climate change-focused initiatives and policies at local, regional, and state levels. While it is beyond the scope of this study to comprehensively evaluate them all, we aim to review those that might be enhanced, modified, or otherwise updated to incorporate a social and energy equity lens. Specifically, there are 11 active programs that the Governor's Office of Energy administers, in partnership with other respective state agencies and private sector stakeholders, that focus on providing energy efficiency, accessibility and funding support, and demographically targeted population assistance.[212] Due to their broad coverage, we briefly outline these programs next, along with some local initiatives, and then provide recommendations on how they might be updated or expanded, based on our findings.

3.3.1 Transportation

To increase the adoption of electric vehicles and expand their health and economic benefits to all populations, policies should be aimed at alleviating barriers to access for underserved communities, largely through the expansion of targeted financing mechanisms and community engagement. Community input should guide the prioritization of alternative modes of personal transportation, such as public transit, biking or walking, and carpooling, as well as additional electric vehicle charging infrastructure investments. Additional investments in community infrastructure measures that reduce vehicle demand by supporting active transportation options, such as biking or walking, could also help to reduce pollution burdens in urban areas—and improve public health through increased physical activity. Achieving socioeconomic- and environmental-equity and public health benefits across the transportation sector also requires a suite of approaches that address existing pollution—including from heavy-duty vehicles—in addition to providing electric vehicle financing for moderate- and lower-income households and small trucking operators, and supporting the expansion of public transit.

Recommendation 1: Design upfront financial incentives to support adoption of electric passenger vehicles in low-adoption rate communities, such as populations of color and low-income communities, who suffer from disproportionally high vehicle fuel-related cost burdens. Incorporate community input to guide electric vehicle charging infrastructure investments which can facilitate electric vehicle adoption among households facing access barriers.

To incentivize electric vehicle adoption, and in partnership with public and private stakeholders, the Nevada Electric Highway program created Level 2[213] and direct current charging stations along Highway 95, between Reno and Las Vegas (Phase I, commencing in 2016), and other major interstate and US highway corridors (Phase II, commencing in 2017).[214, 215, 216] By strategically locating chargers along heavily travelled corridors, at hotel or overnight lodging locations, restaurants, shopping centers, and other travel areas that offer comforts such as restrooms, the program makes traveling across Nevada more electric vehicle-friendly. However there are areas for improving economic equity throughout this program.

212 Governor's Office of Energy. "Programs." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Active_Programs/

213 Alternating Current Level 1 (120v), Alternating Current Level 2 (240v), and Direct Current are common fast charging outlets. Home charging systems can include fast chargers, but are typically slow or "trickle" charging.

214 Governor's Office of Energy. "Nevada Electric Highway." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Nevada_Electric_Highway/

215 Governor's Office of Energy. Factsheet: Nevada Electric Highway. *State of Nevada* (2020).

216 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

From our findings (see **Figure 19**), the majority of public charging stations in the Las Vegas metropolitan region are located in census tracts with low Demographic Index rankings, clustered at shopping malls, casinos, and other large venues near the Arts District and the Las Vegas Strip. Ensuring that public charging infrastructure is accessible to residents in the northern and eastern parts of the Las Vegas metropolitan area, where populations are majority people of color, majority low-income, and have particularly high fractions of linguistically-isolated households, could help the state to reach households who likely face high barriers to electric vehicle adoption.

Ownership of these charging stations is currently left to the energy service providers, which includes rural cooperatives and power districts, but this could be expanded to benefit more low-income and communities of color by also incentivizing ownership and operations of these stations by the local community, in addition to those within the cooperative or power district. While cooperatives are technically owned by the communities they serve, in general, rural cooperative boards and committees are predominantly White, leaving racially diverse rural populations without decision-making authority into how the clean energy transition will occur, over what timeframe, at what financial cost to use services, and at what gain for member owners.[217,218,219] Accordingly, state and local policy makers should encourage cooperative boards and committees to be representative of customer communities.

Currently, electric vehicles are typically purchased by higher-income households nationally,[220] though we do not have data specific to Nevada electric vehicle ownership by income. Additionally, a study focused on the California electric vehicle buyers market shows that electric vehicles are disproportionately purchased by White populations, even when adjusted for income, which may hold true in Nevada as well.[221] Existing incentives, such as tax credits or post-purchase rebates for electric vehicle adoption, benefit those with higher income tax burdens, and do not help alleviate the upfront socioeconomic barriers to vehicle electrification for communities of color or moderate- to lower-income Nevadans. Upfront financing and subsidies to encourage electric vehicle adoption for communities of color and moderate- to lower-income communities are needed to ensure that electrification is more accessible to these populations. Additional financing measures can include point-of-sale rebates, low-interest loans for low- and moderate-income customers to purchase fuel-efficient and electric vehicles, and additional rebates for trading in inefficient older vehicles for cleaner models. It may also be valuable to facilitate the secondary market for electric vehicles.

As vehicles are electrified, the accompanying public charging infrastructure will need to maintain pace, and private programs such as those offered by NV Energy,[222] and government programs like the Nevada Electric Highway program should continue to be funded and expanded, with a focus on both highly polluted rural areas and dense urban areas with multifamily buildings, to ensure these regions do not lag behind in adoption (current stations are shown in **Figure 19**). While Nevada must continue to expand intrastate charging infrastructure, expansion of infrastructure to support interstate travel is also advisable as interstate commerce is necessary for state-wide economic stability. Interstate electric vehicle travel will help Nevadans, and surrounding neighboring states, by expanding air quality benefits and clean transportation options to more people. Collaborative multi-state approaches to decarbonization are one effective way to realize the benefits of electrification. The Electric Vehicle Plan for the West (named the Regional Electric Vehicle West Plan by its signatories), a memorandum of understanding between Nevada and seven other western states, is an example of how a multistate effort can further electric vehicle adoption by making it more convenient and

217 Yanez, Miguel, *et al.* Equitable Beneficial Electrification for Rural Electric Cooperatives. *Environmental and Energy Study Institute* (2019).

218 Ross, Lauren, *et al.* The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency. *Energy Efficiency for All, American Council for an Energy-Efficient Economy* (2018).

219 Labor Neighbor Research and Training Center and ACORN International. The Rural Power Project: A Research & Advocacy Report (2016).

220 Slowik, Peter and Michael Nicholas. Expanding Access to Electric Mobility in the United States. *The International Council on Clean Transportation* (2017).

221 Muehlegger, Erich and David Rapson. Understanding the Distributional Impacts of Vehicle Policy: Who Buys New and Used Alternative Vehicles? *National Center for Sustainable Transportation Research Report* (2018).

222 NV Energy. “Electric Vehicles.” Accessed: Nov. 2020. Available at: https://www.nvenergy.com/cleanenergy/electric-vehicles

accessible to drive an electric vehicle across multiple states via an electric vehicle corridor with sufficient charging infrastructure.[223]

Recommendation 2: Accelerate medium- and heavy-duty truck electrification and emission reductions by (1) prioritizing the retirement of old, high-emitting heavy-duty and medium-duty trucks, (2) providing sufficient financial incentives for small businesses to convert their trucks, (3) rerouting trucks away from dense, urban areas with high cumulative environmental burdens, (4) limiting diesel truck idling, and (5) creating enforceable in-state targets to support interstate trucking electrification goals.

Within the decarbonization modeling scenarios, passenger vehicles are electrified at a faster rate than trucks. Policies are needed to help accelerate the electrification of trucks, most of which are medium-duty and heavy-duty vehicles and trailers, and responsible for a disproportionately high fraction of the sector's NO_x and $PM_{2.5}$ emissions relative to their fraction of vehicle miles traveled. Multi-state initiatives with enforceable in-state targets are key to the facilitation of truck electrification in particular, due to high interstate truck traffic. These initiatives can help reduce pollution along interstate corridors, where emissions from on-road vehicles are most dense.

A multi-state approach may prove to be useful to target this sector, such as the Pledge to Develop Action Plan to Eradicate Toxic Diesel Emissions by 2050, a joint memorandum of understanding which aims to ensure all new medium- and heavy-duty vehicles, such as delivery trucks, buses (school and transit), and other commercial vehicles, are zero-emission by 2050.[224,225] While this joint memorandum is a first step, neither the 2050 target nor the intermediary 2030 target—that 30 percent of new sales of medium- and heavy-duty vehicles be zero emission—are binding. More aggressive policies, such as California's Advanced Clean Trucks rules, which requires truck manufacturers to produce and make available for sale zero-emission vehicles,[226] could be used to ensure emission reductions are achieved in the near term. Private electrification efforts, such as the Electric School Bus Incentive by NV Energy, which offers rebates for electric bus purchases, could be further developed to expand conversion.[227] As noted in the MOU, strategic deployment of vehicle charging infrastructure, especially along urban interstate corridors, as well as beneficial vehicle charging rate design are needed to facilitate electric vehicle adoption within the trucking industry.

While large fleet owners and operators may be able to absorb some or majority of the costs of converting their fossil-fueled fleets into electric vehicles, smaller fleets and independent truckers may not be able to do so without additional financial support.[228, 229] Small owner-operator truckers are typically micro enterprises owned or leased by a single person,[230] and access to capital to improve or buy new equipment or vehicles is severely limited. Any effort to electrify the trucking industry will need to incorporate upfront financing mechanisms[231] for these small and micro enterprises. For example, the Volkswagen Settlement Fund (also known as the Diesel Emission Mitigation Fund), which provided grants to incentivize the early retirement of eligible diesel vehicles and maximized awards in 2019, could have included

223 National Associate of State Energy Officials. Regional Electric Vehicle Plan for the West (2019).

224 California Air Resources Board. Multi-State Medium- and Heavy-Duty Zero Emissions Vehicle Memorandum of Understanding (2020).

225 Northeast States for Coordinated Air Use Management. 15 States and the District of Columbia Join Forces to Accelerate Bus and Truck Electrification. ledge to Develop Action Plan to Eradicate Toxic Diesel Emissions by 2050 (2020).

226 California Air Resources Board. Advanced Clean Trucks. Accessed Oct. 2020. Available at: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks/about

227 NV Energy. Electric School Bus Incentives. Accessed Nov. 2020. Available at: https://www.nvenergy.com/cleanenergy/electric-vehicles/school-buses

228 Leung, Jessica and Janet Peace. Insights on Electric Trucks for Retailers and Trucking Companies. *Center for Climate and Energy Solutions* (2020).

229 Romero, Ezra David. California Electric Trucks Standard is First of Its Kind; Pandemic Leads Trucking Industry to Question Its Viability. *Capital Public Radio*. Apr. 3, 2020.

230 Owner-Operator Independent Drivers Association. OOIDA.com. Accessed: Dec. 2020.

231 Satterfield, Charles and Nick Nigro. Assessing Financial Barriers to Adoption of Electric Trucks. *Atlas Public Policy* (2020).

preference towards these smaller owner-operators.[232] In the decarbonization scenarios, small and independent fleets that continue to operate non-electrified trucks may be further financially disadvantaged because they will be required to purchase more expensive zero-carbon fuels to meet the 2050 climate goals, unless policy intervention is implemented.

Other efforts to mitigate truck pollution, such as rerouting trucks to less populated areas or limiting idling (as of 2020, limited to 15 minutes[233]) and wait times in weighing or check-in stations and in residential neighborhoods, could reduce air pollution and be more immediately implemented. Additional measures that replace aging and inefficient trucks should also be considered to address legacy environmental and sociodemographic disparities in electric truck adoption, ownership, and access. However, further investigation is needed to ensure that these measures do not unduly burden small and micro trucking owner/operator enterprises, or fail to benefit communities with disproportionately high cumulative pollution.

The placement of new charging stations must consider where current and future trucking routes and pollution are located, which the Nevada Electric Highway program could be further leveraged to project the location of future stations. New infrastructure should not financially overburden those communities already dealing with these existing environmental and socioeconomic disparities, but should instead provide economic incentives to those communities to electrify through local infrastructure ownership, job creation, and revenue generation. This infrastructure build-out needs to be coupled with the safe retirement of fossil fueling stations through government- and fossil fuel company-financed dismantling and soil and water remediation programs.

Recommendation 3: Coordinate efforts by local, regional, and state governments—with outreach to local communities—to expand electrified low- or zero-fare public transit, where appropriate, to reduce transit-related pollution and overall vehicle travel while improving transit access for mobility-limited households.

Nevada has taken several steps towards electrifying the transit portion of the transportation sector over the years, with an initial push in 2007 with SB 161 to reduce driver administrative burden by exempting hybrid electric vehicles from emission control testing,[234,235] and incentivizing electric vehicles (private passenger and public transit) through a variety of initiatives and policy carve-outs.[236,237] Nevada should avoid emission control testing exemptions[238] which could contribute to more polluting, non-electric vehicles on the road. Public transit build-out is a core component of the Low Demand decarbonization scenario, which yields the greatest emission reductions and lowest net cost, however it should have a community-guided design and implementation plan. In addition to providing community-wide benefits, affordable and electric public transportation will particularly benefit several populations, including communities of color and low-income households, which have historically lagged behind in electric vehicle adoption and have the lowest

232 Nevada Division of Environmental Protection. Volkswagen Settlement Fund. *State of Nevada.* Accessed: Nov. 2020.

233 NV Rev Stat §445B.576. Accessed: Nov. 2020.

234 Department of Motor Vehicles. Minutes of the Advisory Board on Automotive Affairs *State of Nevada,* Apr. 3, 2007.

235 Department of Motor Vehicles. "Nevada Emissions Control Program." *State of Nevada.* Accessed Nov. 2020. Available at: https://dmvnv.com/emission.htm

236 Rosenblat, Laurent and Marie K. Steele. Electrifying Nevada's 21st-Century Transportation System: Actions, Opportunities, Aspirations. *E-centricity* (2019).

237 Alternative Fuels Data Center. "Nevada Laws and Incentives." *US Department of Energy*. Accessed Nov. 2020. Available at: https://afdc.energy.gov/laws/all?state=NV

238 The classic car vehicle license plate was used to bypass vehicle emission testing for cars that traditionally were not considered to be "classic." Since the 2011 passage of less stringent enrollment standards for vehicles to be considered classic, the number of vehicles with the exemption ballooned and in 2015, AB 146 passed to address the issue. In 2016, a study by the Nevada Division of Environmental Protection provided recommendations to stop the exploitation of the classic car loophole (Duggan, Brian. Ever Wonder How that Junker Got a Nevada 'Classic Vehicle' Plate? Here's How It's Legal. *Reno Gazette Journal.* Aug. 8, 2018. Jaunaraj, Sig *et al.* Report on Assembly Bill 146 Study Concerning the Inspection and Testing of Motor Vehicles and Systems for the Control of Emissions from Motor Vehicles in Nevada. *State of Nevada* (2016). Department of Motor Vehicles. Nevada Emissions Control Program, *State of Nevada.* Accessed Dec. 2020. Available at: https://dmvnv.com/emission.htm#Classic).

access to any kind of vehicle.[239] For example, the Regional Transportation Commission in Washoe County has already begun to convert to electric buses through their RTC Electric Bus Initiative, which increases the use of electric buses, charging stations, and energy storage, and achieves benefits such as easier bus maintenance and reduced electric utility demand charges.[240] Current fossil fuel-reliant public transportation could be phased out and replaced with electric school and transit buses, prioritizing aging fleets and those operating along polluted routes.

Nevada also recently allocated $200 million in private activity bonds to XpressWest, a fully electric high-speed rail project between Los Angeles and Las Vegas that will begin operating in 2023.[241] Serving as an alternative mode of transport to the third most popular flight path in North America (3,887,843 scheduled seats in 2019),[242] the rail line could potentially reduce criteria air pollutant emissions from the Las Vegas McCarran International Airport, Nevada's highest-emitting point source of NO_x, VOCs, SO_2, and health-damaging hazardous air pollutants. Reducing ground-level aircraft pollution could help to reduce the cumulative environmental burdens in census tracts adjacent to the airport, which are majority people of color and low-income and are also in close proximity to vehicle pollution from Interstate 15. The project could also serve as a blueprint for future expansion of electrified rail lines to replace other emissions-intensive intrastate and interstate routes in Nevada.

Expanded public transit infrastructure, such as mass transit trains or high-speed buses, could help alleviate congestion and pollution burdens in urban areas and increase transit access in underserved communities. Public transportation may even be considered a utility in its own right, as it is an essential provider of public goods and its broad accessibility is needed for fuller economic participation.[243, 244] However, investments should be informed by community feedback, and should include community-driven solutions for public transit implementation, supporting accessibility and affordability, while limiting the negative impacts of displacement and gentrification.[245, 246, 247] A potential initiative Nevada may consider adopting is the Innovative Clean Transit rule from California, which supports transitioning all public buses to zero-emission technology.[248] Additional city planning to support active transit options such as biking or walking can yield bonus individual and public health benefits. For example, the RTC Smart Trips service in Washoe County shows how using alternative modes of transportation can be implemented between local businesses, employees, and consumers.[249] To continue to move the state towards more accessible electrified transit options, efforts will require coordination between state, regional, and local government agencies.

239 Hsu, Chih-Wei and Kevin Fingerman. Public Electric Vehicle Charger Access Disparities Across Race and Income in California. *Transport Policy* 100 (2021): 59-67.

240 Regional Transportation Commission. The RTC Washoe Electric Bus Initiative (2017).

241 Ohnsman, Alan. Los Angeles-To-Las Vegas High-Speed Train Wins $200 Million Nevada Bond Allocation. *Forbes.* July 24, 2020.

242 OAG Aviation Worldwide Limited. Busiest Routes 2020 (2020).

243 Templeton, Carter. Transportation as Utility. *The Eno Center for Transportation* (2013).

244 Stomberg, Joseph. The Real Reason American Public Transportation is Such a Disaster. *Vox* (2015).

245 Padeiro, Miguel, *et al*. Transit-Oriented Development and Gentrification: a Systematic Review. *Transport Reviews* 30 (2019): 733-754.

246 Turrentine, Jeff. When Public Transportation Leads to Gentrification. *NRDC,* June 1, 2018.

247 Chapple, Karen and Miriam Zuk. Chapter 4 - Transit-Oriented Displacement: the Role of Transit Access in the Housing Market. *Transportation, Land Use, and Environmental Planning* (2020): 55-79

248 California Air Resources Board. "Innovative Clean Transit Regulation Fact Sheet." Accessed Oct. 2020. Available at: https://ww2.arb.ca.gov/resources/fact-sheets/innovative-clean-transit-ict-regulation-fact-sheet

249 *Regional Transportation Commission.* "RTC Smart Trips." Accessed Nov. 2020.

Available at: https://www.rtcwashoe.com/public-transportation/rtc-smart-trips/

3.3.2 Residential Buildings

Our findings for the residential sector, combined with summarizing the results of public data sources and analysis, indicate that socioeconomically and demographically vulnerable communities, including low-income communities, communities of color, and the renting population, lag in access to clean energy technologies,[250, 251] leading to the inequitable distribution of clean energy benefits (e.g. utility bill savings and reduction of indoor air pollution) away from these communities. In addition, air pollution from buildings—notably particulate matter and NO_x—is not distributed evenly across the state and can vary dramatically by fuel type and community, including substantial contributions from wood in rural areas.

Meanwhile, residential energy cost burdens tend to be highest for low-income neighborhoods and for communities of color across all income levels, as shown in **Figures 25** and **27**, even though energy consumption tends to be largest for higher-income, Whiter neighborhoods (as shown in **Figures 26** and **28**). Thus, policies aimed solely at reducing greenhouse gas emissions may not, by themselves, alleviate residential energy cost burdens for Nevada's economically overburdened populations nor reduce building pollutant emissions, particularly from wood fuel. Complementary policies will be needed to ensure that low-income households, communities of color, and rural populations have access to, and benefit equitably from, clean energy technologies.

Weatherization programs offer cost savings through demand reduction and can be implemented at scale with relative ease. Some weatherization programs focus solely on lower income households, such as the Weatherization Assistance Program,[252] which is for homeowners and renters, with cost sharing provisions for landlords. There is no direct cost for participants, and the program is administered by nonprofit agencies who specialize in their respective service areas. *However, as our findings suggest, using only income to identify underserved households might miss other populations with disproportionately high energy cost burdens.*

Two homeowner-focused weatherization programs in Nevada, without low-income requirements, also offer energy savings to participants. The Direct Energy Assistance Loan program, a public sector pilot program, provides interest-free loans via payroll deduction to select (i.e. 139) Nevada government homeowning-employees for energy efficiency and weatherization upgrades to their homes. Through 24 eligible measures for upgrades, this pilot showed 2,548 kWh and 350 therms of average energy savings annually per home; however the pilot project is no longer accepting applications.[253, 254, 255] The Home Energy Retrofit Opportunities for Seniors (HEROS) program focuses on providing no out-of-pocket cost weatherization for low-income senior homeowners.[256, 257] Programs focused only on homeowners, however, exacerbates wealth disparities by increasing home values, which is beneficial for some homeowners but can have displacing effects on lower and fixed income homeowners and the renting population at large. Nevada also has a higher renting

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

251 Sunter, Deborah, *et al*. Disparities in Rooftop Photovoltaics Deployment in the United States by Race and Ethnicity. *Nature Sustainability* 2.1 (2019): 71-76.

252 Nevada Housing Division. "Weatherization Assistance Program." Accessed Nov. 2020. Available at: https://housing.nv.gov/programs/Weatherization/

253 Governor's Office of Energy. "Direct Energy Assistance Loan." *State of Nevada*. Accessed Nov. 2020. Available at: https://energy.nv.gov/layouts/Page_Style_1.aspx?id=132388

254 Governor's Office of Energy. Fact Sheet: Direct Energy Assistance Loan Program. *State of Nevada* (2019).

255 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

256 *Ibid.*

257 Governor's Office of Energy. "Home Energy Retrofit Opportunities For Seniors." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Home_Energy_Retrofit_Opportunities_for_Seniors_%28H_E_R_O_S_%29/

population compared to the national average,[258] which can be more vulnerable to rent increases caused by increasing property values. *Expanding these programs to otherwise eligible government employees (for the Direct Energy Assistance Loan program) or seniors (for HEROS) who do not own their homes could provide these energy savings to tenants and their landlords alike. The eligibility criteria could be modified for tenants to allow eligibility measures that would provide the most impact savings for this demographic.*

Recommendation 1: Ensure equitable access to the economic and health benefits of energy efficiency, distributed energy resources, and electrification, beyond home- and landowners.

Targeted incentives, financing, and outreach can help reduce barriers to clean energy adoption for underserved households, including those who struggle with high energy cost burdens. In general, building decarbonization should include (1) easily accessible funding mechanisms for financially disadvantaged communities, including upfront financing, (2) building efficiency measures to reduce overall energy demand (including a focus on communities that face higher energy costs due to inefficient electric equipment in drafty or poorly insulated buildings), (3) educational outreach to local communities regarding the benefits of electrification, distributed energy resources, and efficiency, and addressing personal or cultural barriers for adoption of clean energy technologies, and (4) further evaluation and removal of the social barriers that low-income communities and communities of color face to adopting these measures. Community feedback can be delivered in numerous forms, including but not limited to forums and workshops, committees for program and project approval, and in advisory capacities throughout program development and implementation.

Adopted in 2018 by the Governor's Office of Energy, the Building Energy Codes program follows the 2018 International Energy Conservation Code for building efficiency standards, prioritizing energy efficiency in new and recently renovated buildings, saving money for beneficiaries of compliance.[259, 260] The program partners with the Building Code Assistance Program, a separate entity which advocates for state- and local-level energy efficiency for all.[261] There is an opportunity to further the mission of the Building Energy Codes program, which currently focuses on homeowners, homebuilders, and state agencies, by expanding accessibility and financing assistance to populations that are traditionally marginalized from the benefits of energy efficiency, including, but not limited to, tenants, populations of color, and moderate- to low-income populations.

To ensure wide decarbonization participation of households facing multiple market barriers, additional market-oriented mechanisms could be implemented. One option is to encourage utility bill-financed energy efficiency upgrades through budget billing (average payment plans) programs. This would evenly spread the cost of upgrades over time, allowing the utility consumer to have consistent, predictable pricing. A second option is to participate in a percentage of income payment plan, which would cap the amount of income spent on electricity utility bills and can be tailored to any population with disproportionately higher energy cost burdens such as communities of color and low-income populations. While our study looked at income and racial minority demographic indicators, it is likely that other indicators should be evaluated as well for energy cost overburdens and participation in a percentage of income payment plan program. A third option is to allow third-party energy service companies to finance the cost of electrification efforts. The service company can guarantee the utility consumer a flat rate for a specified period of time, which can allow utility consumers financial access to larger, more expensive upgrades they otherwise could not afford through budget billing. In this approach, policy provisions will be needed to protect household interests by mandating rate-stabilizing contracts with the third-party energy service companies during the electrification upgrade payback period, and by providing additional incentives to encourage deep building retrofits and full electrification.

As building efficiency and electrification measures are widely adopted, community engagement should inform the balance between creating financial incentives for

258 US Census Bureau. "Nevada QuickFacts" (2019). Available at: https://www.census.gov/quickfacts/fact/table/NV,US/PST045219

259 Governor's Office of Energy. "Building Energy Codes." *State of Nevada*. Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Building_Energy_Codes/

260 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

261 Building Code Assistance Program. "Building Code Assistance Program." Accessed Oct. 2020. Available at: http://bcap-energy.org/

private residential property owners to make upgrades and securing housing affordability and stability for tenants. At a minimum, decarbonization policies should be paired with affordable rent and anti-displacement provisions. Publicly-funded mechanisms such as grants to landlords of single-family homes, small multi-family properties, and other small businesses that lease out space, should be available to alleviate the need to increase tenant rents while providing capital for upgrades without undue burden on landlords. The grants should include provisions to prevent program abuse, and measure how capital upgrades are implemented. It is important to protect both small landlords and tenants from bearing more than their share of the work to transition to a clean energy economy.

Recommendation 2: Plan for a gradual, geographically targeted phase-out of the natural gas distribution system, with targeted rate-stabilization for non- or late- electrification adopters and utility bill subsidies for populations with high energy cost burdens.

As demonstrated in **Figure 32**, those households which are unable to participate in the adoption of clean energy technologies risk facing escalating utility bills to cover the costs of an aging gas distribution system in transition. As electrification progresses, it is important to strategically target the legacy fossil fuel infrastructure phase-out from one region to the next (i.e. pruning infrastructure) and balance utility bill rates throughout the state. Any such phased approach should integrate socioeconomic equity considerations, such as income and race (which our findings show bear disproportionately higher energy cost burdens), into prioritizing which regions and populations have their buildings electrified first, accounting for existing environmental health burdens and historical access to clean energy technology, among other factors.

This approach will avoid service disruptions, eliminate long-term maintenance costs, and minimize expensive retrofits and upgrades during the transition. It also provides the additional benefit of removing safety hazards associated with aging natural gas distribution infrastructure. Our findings further underscore the importance of policy interventions that provide bill protections and make clean energy technologies accessible to households with high baseline energy cost burdens during this transition. A more equitable approach would require that non-adopters are not left behind shouldering the full cost of stranded assets, and that economically vulnerable and demographically underserved communities are among the first to transition off of the soon-to-be-retired fossil fuel system. Additionally, those without reliable access to electricity, particularly in rural or tribal nation areas, should be prioritized targeted for clean energy adoption.

Recommendation 3: Consider focused deployment strategies for distributed energy resources to maximize public health and climate resilience benefits, including an expansion of residential solar and energy storage systems.

Although utility scale projects are perceived to be the most cost-effective per megawatt-hour generated (excluding necessary but deferred transmission-related investments), distributed resources may confer additional benefits to Nevadans that should be considered but are not captured by solely weighing costs and generation capacity. Clean energy deployment in certain population subsets can be particularly beneficial for reducing energy cost and pollution burdens, improving climate resilience, and maximizing public health benefits. Policymakers should therefore consider how to maximize these co-benefits when weighing the deployment of distributed energy resources such as solar (e.g. community, rooftop, etc.), energy storage, microgrids, and energy efficiency measures as compared to utility-scale projects.

Rural households, customers who rely on electricity for medical needs, low-income households, or households of color in climate vulnerable areas areas (e.g. high wildfire risk, high number of extreme heat days, etc.) may face trade-offs between affording their electric bills and risking climate-related health complications or potentially life-threatening power shut offs during or in anticipation of natural disaster events (e.g. wildfires). For example, NV Energy notified customers in 2019 that power could be cut in order to proactively reduce the risk of climate change-induced wildfires.[262] Climate vulnerable households would particularly benefit from improved access to reliable and affordable air conditioning and air filtration systems, and medical baseline customers in particular would benefit from

262 Spillman, Benjamin. Nevada Utility Could Cut Power in Fire-Prone Areas to Reduce Risk. *Reno Gazette-Journal,* June 14, 2019.

the resilience and reliability of home solar and storage systems.

Our calculations in **Table 3** provide illustrative examples of how Nevada may leverage distributed energy deployment to maximize public health and resilience co-benefits. For example, our results show that the electricity needs of all medical baseline customers in heat-vulnerable counties could be covered by 2030 if 15 percent of all rooftop solar installations were allocated to these households. Similarly, the electricity needs of all low-income rural households could be covered by 2030 if two percent of all rooftop solar installations were allocated to these households, even under the assumption that distributed solar resources comprise a relatively minority of 2030 solar installations. Solar + storage and microgrids at community sites such as schools, community centers, and clinics can also provide resilience hubs where community members can access air conditioning and ventilation, refrigerate medicines, charge cell phones, and otherwise gather in emergencies.

Future household energy needs should be evaluated based on potential climate impacts. As a hypothetical example, replacing an existing natural gas heating system with an air source heat pump might not meet existing incentive cost-effectiveness requirements, but if a household needs to add air conditioning as the summers grow increasingly hot, an air source heat pump might be significantly more cost effective than replacing an existing heating system and adding a new HVAC system. Similarly, a solar + storage system might be more expensive than the existing grid supply of electricity, but might be more cost competitive if a customer is considering the alternative of adding a diesel generator for backup. For heating spaces only, a geothermal (i.e. ground source) heat pump is another alternative to natural gas.[263,264] Current incentive structures and cost-effectiveness provisions may have to be updated to reflect combined decarbonization and climate resilience goals. As the State and local governments develop plans and policies for climate resilience,[265,266] revising these incentive structures accordingly may be useful to maximize climate mitigation and adaptation strategies.

Electricity access is not equitably distributed throughout the state, and while data for tribal communities is limited for Nevada, consistent, reliable, and accessible energy is not typically ubiquitous in tribal nations in other states,[267] and there is likely a need for the clean energy transition to focus on and correct the shortcomings of existing energy infrastructure where it exists in Nevada for these populations. Distributed energy resources such as solar power, coupled with resilience-focused technologies like battery storage, can provide a powerful and reliable clean energy source for tribal nations and rural communities. Distributed energy resources, in addition to utility-scale and community-scale renewable generation, should be supported by publicly-funded financing mechanisms that tailor solutions for historically underserved and underrepresented communities to have full and reliable access to clean electricity.

Recommendation 4: Prioritize early electrification of buildings using unconventional or alternative fuels (e.g. fuel oil, propane, wood, etc.) to reduce energy cost burdens and improve health outcomes in rural areas.

Although alternative fuels such as wood and propane are infrequently used in homes compared to electricity and natural gas, both provide good targets for near-term electrification. Propane is comparatively expensive, and wood is responsible for a large fraction of Nevada's residential particulate matter emissions but is not replaced in carbon-focused decarbonization scenarios. Specifically targeting buildings that burn propane can help reduce high energy cost burdens, while targeting buildings that burn either propane or wood can improve ambient and indoor air quality, potentially reducing pollution burdens in rural areas which can lead to better health outcomes.

However, electrification of wood heating is not always the most cost-effective option given the low cost of wood, and there may be social and cultural ties to

263 Gellerman, Bruce. How a Climate Change Nonprofit Got Eversource Thinking About a Geothermal Future *WBUR*, Jan. 13, 2020.

264 Roberts, David. The Earth Itself Could Provide Carbon-Free Heat for Buildings. *Vox*, Nov. 13, 2020.

265 Climate Initiative. "Our Goals." *State of Nevada.* Accessed Dec. 2020. Available at: https://climateaction.nv.gov/our-goals/

266 Barker, Lynne *et al.* City of Reno Sustainability & Climate Action Plan 2019-2025 (2019).

267 Office of Indian Energy Policy and Programs. Strengthening Tribal Communities, Sustaining Future Generations. *US Department of Energy* (2017).

burning wood beyond just heating purposes. One option to maintain wood burning while reducing pollution is to replace aging conventional and EPA-certified wood stoves with wood pellet stoves, which have significantly lower particulate matter and VOC emission rates. If energy efficiency and weatherization measures are implemented in buildings with high indoor emissions, proper air ventilation systems should be required to improve indoor air quality, since efficiency measures may limit outdoor and indoor air exchanges and increase indoor air quality risks.[268]

Though propane and wood are the most common unconventional residential fuels and are accordingly highlighted in our analysis and recommendations, Nevada has higher rates of fuel oil use than much of the Western US, and a small number of Nevada households rely on coal to heat their homes. Like propane and wood-using households, electrifying these homes should also be a key component of decarbonization policy to maximize public health co-benefits.

Additional Community Feedback

Based on the discussions we held with community organizations, we also recommend 1) support for electrification of mobile homes and buildings, allowing better utility cost stabilization and 2) further community feedback considerations for large-scale projects. Currently, mobile homeowners pay park owners for their utilities in general, as separate metering is uncommon. Given the aging of mobile home parks, many park landowners charge maintenance, retrofitting, and upgrade fees to homeowners to bring the homes to current aesthetic and safety standards, creating a large potential expense for homeowners. Electrification efforts, with energy equity provisions including cost-sharing between homeowners and tenants, could be encouraged by modification to existing legislative policies or creation of new policies. Additionally, the US Bureau of Land Management works with Nevada to perform environmental impact assessments and statements under NEPA[269] for large-scale projects, and these plans should require permitting agencies for residential and commercial facilities to review and use community-led input, particularly from historically excluded communities, prior to project approval. While some entities may already consider community-input, our discussions with community organizations indicated that a more holistic, state-wide approach that receives input from all property stakeholders, including but not limited to property renters, property owners, and property managers would be beneficial.

268 Underhill, Lindsay J. *et al.* Simulation of Indoor and Outdoor Air Quality and Health Impacts Following Installation of Energy-Efficient Retrofits in a Multifamily Housing Unit. *Building and Environment,* 170 (2020).

269 Bureau of Land Management. “Nevada Planning and NEPA.” *US Department of the Interior.* Accessed Dec. 2020. Available at: https://www.blm.gov/programs/planning-and-nepa/plans-in-development/nevada

3.3.3 Commercial Buildings

Unlike the residential sector, the commercial sector lacks granular spatial and emissions data and we were unable to conduct a detailed analysis of commercial buildings. However, Nevada already implements a number of targeted renewable energy and energy efficiency programs and initiatives in the commercial sector; we outline a select few below. Nevada can further these programs, along with robust data collection efforts, to decarbonize this sector efficiently, and with more economically and environmentally equitable outcomes.

Recommendation 1: Expand commercial sector programs to provide more socioeconomically equitable outcomes by requiring cost-savings from decarbonization measures be split between stakeholders (landlords, owners, developers, tenants, and the surrounding local community).

To incentivize new, non-residential building construction and existing building renovations to meet green building standards, Nevada's Government Office of Energy uses the Green Building Tax Abatements programs. The program provides partial property tax abatements, between 25 percent to 35 percent for up to 10 years for projects which use either the LEED (Silver or greater) or Green Globes (2 globes or greater) rating systems criteria. These two systems rate buildings based on a set of environmentally sustainable design, construction, and operation criteria.[270], [271] While some social equity metrics are included in these industry standards, the whole of these standards focus on environmental sustainability. Additional social equity-focused standards could be adopted or direct social equity metrics requiring commercial tenants receive a portion of the tax abatement through lease concessions or tenant improvements.

As with all the other economic sectors, community input, feedback, and representation mechanisms must be considered broadly across commercial real estate stakeholders such as commercial building owners, building management and operators, building tenants (owners, employees, and contractors), and residents that live in or near mixed use commercial spaces. While commercial building tenants may want to electrify their operations based on consumer market preferences, they have limited-to-no control over the commercial building shell and building systems, limiting overall building efficiency and indoor air pollution control. As commercial facilities are upgraded for energy efficiency, ventilation systems should also be upgraded to allow for higher quality indoor air, particularly when the space is used for cooking or other particulate-emitting processes.

Recommendation 2: Expand renewable energy and energy efficiency programs to ensure historically pollution- and socioeconomically-overburdened populations, beyond low-income communities, such as populations of color, tribal nations, and tenants, benefit from commercial sector cost-savings.

The Lower Income Solar Energy Program, piloted in 2013 from AB 428 and made permanent in 2017 via SB 145, provides financial incentives to install and use solar energy for businesses that primarily serve low-income households, either directly through low-income housing, or indirectly as a product or service provider such as a health clinic or food bank.[272] The result is more affordable access to clean energy resources. As of December 2019, the program is "fully subscribed" and through this program more than "1,000 lower income households throughout the State are benefiting."[273]

Based on our findings, low-income households, as well as other traditionally marginalized communities, have high average energy cost burdens. Beyond low-income

270 Governor's Office of Energy. "Green Building Tax Abatements." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Green_Building_Tax_Abatements/

271 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

272 Governor's Office of Energy. Lower Income Solar Energy Program. *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Lower_Income_Solar_Energy_Program/

273 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

households, we found people of color and those with limited educational attainment, also bear high energy cost burdens, with neighborhoods of color experiencing higher energy burdens on average than White neighborhoods of similar socioeconomic status (**Figure 27**). Social barriers to clean energy access beyond income are likely present and exacerbate inequitable financial burdens to affected populations. Therefore, we recommend that the Solar Energy Program be expanded beyond low-income serving businesses, and include businesses that service significant portions of people of color and other Nevadans who have higher energy cost burdens and may lack access to affordable, clean energy.

The main mission of the Performance Contract Audit Assistance Program, launched by the Governor's Office of Energy in 2014, is to improve energy savings within commercial and built environments, owned and/or used by Nevada's state agencies, educational facilities, and government districts (i.e. counties, cities, etc.). Instead of front-loading the capital expenses of these upgrades and retrofits, the program allows lower-cost, steady payments over time. The lower-costs are predetermined from calculating the energy cost savings from utility or operational expenses, which are then contractually repaid over time for the upgrades and retrofits. This leaves capital budgets intact and guarantees savings. Improvement qualification criteria is flexible and broad, based on the needs and assessment of the government facility, and may include anything from HVAC upgrades to irrigation systems. All of the audits identify specific energy saving strategies for that government entity, in order to inform and guarantee the subsequent financial mechanism to contractually lock in those savings, and a pre-approved, qualified Energy Service Company (ESCO) performs the audits.[274, 275, 276] We recommend the state's Public Works Division, who currently qualifies third-party ESCOs, consider social and economic equity criteria in their selection process of the ESCOs, including but not limited to traditionally underrepresented or underfinanced small businesses, such as those with racial- or gender-minority ownership. Since ESCOs can potentially have a job-generating impact on the local economy, further analysis is needed to evaluate workforce opportunities and limits of using this third-party auditing system from a social and economic equity lens. Our study does not cover workforce equity, however, a future companion study will consider how workforce and ownership of contractors may further broaden the economic benefits of deep decarbonization.

274 *Ibid.*

275 Governor's Office of Energy. "Performance Contracting Programs." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Performance_Contracting_Programs/

276 Governor's Office of Energy. Fact Sheet: Performance Contract Audit Assistance Program. *State of Nevada* (2020).

3.3.4 **Electricity Generation**

Our power sector analysis yields two key findings from a climate, environmental health, and environmental- and socioeconomic-equity perspective: first, develop policy mechanisms to ensure remaining gas plants are phased out responsibly without adding stressors to pollution-overburdened vulnerable communities; and second, ensure that renewable energy adoption more equitably benefits communities across socioeconomic strata. New policy initiatives should prioritize communities that are already disproportionately burdened by environmental pollution and health and socioeconomic inequities. From a pollution standpoint, it is also necessary to retire the state's remaining coal generation, but this phase-out is largely underway. Below, we provide the key policy recommendations that have emerged from the technical findings and conclusions in this report.

Recommendation 1: Ensure that power plants left online for reliability are 1) not disproportionately located in socioeconomically disadvantaged communities with high cumulative environmental burdens and 2) pruned with priority given to pollution overburdened neighborhoods.

Many of Nevada's power plants are in rural areas, but the state's urban plants are disproportionately located in low-income communities and communities of color, including within the Las Vegas ozone nonattainment region (**Figure 37**). In the Core scenario some natural gas plants will remain online for reliability for decades, a strategy which risks leaving these facilities operational in urban areas with high concentrations of populations of color and low-income residents. As natural gas plants remain online for reliability, more renewable energy options should be considered for reliability and our findings highlight this need. For example, from our findings, to meet the 2030 target, the state may need to expand solar to provide nearly ⅓ of in-state electricity, which triples current capacity. While rapid renewable energy adoption, coupled with energy efficiency measures, will reduce the vast majority of power sector air pollution, these natural gas plants still run a risk of continuing to operate to meet peak demand on hot summer days when ozone concentrations are already elevated.

As a reliabilable alternative, Nevada should prioritize replacing these natural gas plants by incentivizing energy storage and other clean energy alternatives to meet local reliability and peak demand needs in urban load pockets (i.e. high demand areas with insufficient delivery or transmission constraints). Even in the Fossil Free scenario, these plants may burn biogas in lieu of natural gas, and similar precautions must be taken to limit criteria air pollutant emissions from these facilities. To address these risks, agencies with jurisdiction could limit the annual capacity factor (i.e. ratio of actual electricity generated over the nameplate or maximum generation capacity) or limit the annual and/or seasonal mass of criteria air pollutants allowed to be emitted, as these facilities are operationally phased out. In addition, infrequent use or retirement of these facilities poses a risk they will become stranded assets abandoned by their owners, which could pose environmental and health hazards to nearby communities, with uncertainty regarding who will bear the financial costs of decommissioning and remediating these sites. Once retired, facility dismantling and soil and water remediation should be funded by the utility companies with oversight by the government, and not left to the local communities. Additionally, local communities should be consulted on how and when to dismantle the facilities in order to minimize personal and work disruption.

Recommendation 2: Ensure equitable economic benefits from utility-scale and distributed renewable energy and efficiency adoption.

In addition to pollution reduction, renewable energy growth can provide benefits in the form of tax revenues and job creation. Furthermore, distributed energy resources such as rooftop solar and efficiency can contribute to resilience and economic benefits, which we discuss in the residential buildings section below. On the utility and community scale, the state of Nevada should work with marginalized communities to develop strategies to build new renewable generation technologies to provide tax revenue and workforce development opportunities.[277] Community-owned, investor-owned, government-owned, and individually-owned assets all inherently benefit

277 Workforce development is beyond the scope of this report but will be forthcoming in a companion report in 2021.

different communities, which may or may not financially benefit the local community the technology is sited in, suggesting the need for multiple ownership and funding mechanisms for renewable generation with preference towards an ownership mix. These considerations should play a role in the state's considerations for renewable energy financing and incentives.

Recommendation 3: Expand electricity generation sector programs to provide more socioeconomically equitable outcomes by requiring cost-savings from decarbonization measures be split between stakeholders (landlords, owners, developers, tenants, and the surrounding local community).

Similar to the split incentive programs in the commercial sector, the Renewable Energy Tax Abatement program also offers partial sales and use tax abatement schemes to encourage the development of renewable electricity generation facilities. Workforce[278] considerations for this program include requiring (1) real estate developers ensure at least 10 years of facility operation (for stabilized jobs), (2) more than half of the job positions are filled by Nevadans, (3) employers provide health insurance, and (4) jobs pay at least 175 percent of the average statewide hourly wage. The average wage for program participants was above $41/hr in 2019, greater than the program requirement. [279, 280, 281] These are valuable workforce requirements, but could be enhanced by further evaluating socioeconomic equity considerations. Using address information from recent projects' applications for the program, we found that most projects are located in rural areas and several are located on tribal lands, both of which could benefit from stable, higher paying jobs, tax revenues, and in the case of tribal nations, lease revenue. Currently, there is no requirement that the Nevada-resident quota must be met by the facility's local community residents, nor that the Nevadans that are hired for these projects must meet socioeconomic or race/ethnicity requirements to reflect the demographics of the local site. We encourage that sociodemographic and economic considerations of the local community be additional requirements for this program.

As with many large development projects, start-up costs can be substantial. The federal American Recovery and Reinvestment Act (ARRA) of 2009 created bridge loan financing for renewable energy projects and supply manufacturers, and energy efficiency and conservation projects, with workforce requirements to buy American goods (when applicable), guaranteed wage floor, and other requirements to benefit project employees.[282, 283,284] While different long-term financing options exist (both federally and state-wide), the Property Assessed Clean Energy (PACE) program is a long-term, low-cost financing option specifically designed for renewable energy projects that is available to developers, thanks to 2017's AB 5.[285] Minimizing start-up financial barriers for projects, coupled with energy equity metrics that ensure equitable development from project conception through final use stages, can be helpful to local communities if implemented with socioeconomic vulnerable populations in mind. Current initiatives such as those under the ARRA and PACE programs can be further evaluated to identify where improvements in energy equity considerations should be made.

278 We selectively cover workforce policies that are already included in the clean energy transition and related to the broader policies and recommendations we analyzed, however we did not conduct a comprehensive workforce review and a further, separate workforce companion study is forthcoming.

279 Governor's Office of Energy. Renewable Energy Tax Abatements. *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Renewable_Energy_Tax_Abatements/

280 Governor's Office of Energy. Renewable Energy Tax Abatements: Requirements. *Governor's Office of Energy.* Available online. Last accessed November 2020.

281 Governor's Office of Energy. "Fact Sheet: Renewable Energy Tax Abatement Program." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/uploadedFiles/energynvgov/content/Programs/RETA%20Fact%20Sheet_March%202019.pdf

282 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

283 111th US Congress. "American Recovery and Reinvestment Act of 2009: Special Terms and Conditions for Procurement." (2009) Available at: https://energy.nv.gov/uploadedFiles/energynvgov/content/ARRA%20SPECIAL%20TERMS%20AND%20CONDITIONS.pdf

284 Governor's Office of Energy. Revolving Loans for Renewable Energy, Energy Efficiency, and Energy Conservation. *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Revolving_Loans_for_Renewable_Energy/

285 Governor's Office of Energy. "Property Assessed Clean Energy." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Resources/Property_Assessed_Clean_Energy_(PACE)/

Additional Community Feedback

The equity discussions we held with community organizations highlighted the need for more formal mechanisms to create workforce retraining programs, specifically targeting workers in mining, gambling, and retail. While workforce development is beyond this study's scope, such retraining could include collaboration between various sector stakeholders (e.g. clean energy industry, infrastructure financing entities, communities where target industries are currently located), regional or state authorities (e.g. Nevada Department of Employment, Training and Rehabilitation), and educational institutions (e.g. post-secondary).

3.3.5 Industrial Sector

Available data on criteria air pollutant emissions from industrial point sources do not adequately distinguish between combustion and non-combustion emissions at the facility-level, making it difficult to identify energy consumption-specific industrial criteria air pollutant emissions. Additionally, data on distributed industrial emissions, such as fugitive emissions (i.e. unintentional emission leaks) from oil and gas transmission infrastructure, are only available at the county-level. Due to these limited data, our recommendations are broad, but are a starting point for decarbonization efforts.

Recommendation 1: Prioritize energy efficiency and decarbonization of fuel use at highly-polluting and energy-intensive industrial facilities such as mining facilities.

Industrial decarbonization efforts should include incentives and financing for energy efficiency measures and fuel switching to renewable hydrogen and electricity, particularly in areas with high cumulative criteria pollutant emissions and near socioeconomically overburdened communities and sensitive populations. Community feedback mechanisms can help identify regions and facilities of concern to prioritize for fuel switching and other pollution reduction measures, and remediation funds should be set aside for retired industrial facilities and mining sites.

Recommendation 2: Electrify non-road industrial equipment and heavy duty trucks serving industrial facilities, as well as transit options that transport workers to industrial sites (e.g. buses, carpooling vans, etc.).

Decarbonizing the industrial sector is more challenging than other sectors due to the difficulty of replacing heat-intensive processes with alternative fuels. Aggressively electrifying mobile sources associated with industrial activity—including off-road equipment, heavy duty trucks, and commuting vehicles such as buses and vans for commuting workers—could help to cut emissions from this sector in the near-term, while further technological improvements are made to facilitate decarbonization of industrial processes.

3.3.6 **Cross-Sector**

Our study reveals several cross-cutting themes across sectors and socioeconomic indicators, including energy cost burdens by income, cumulative emissions, and energy inaccessibility and financing hurdles. There are numerous programs (full- and pilot-scale) and initiatives that have already been completed or are no longer accepting applications that relate to renewable energy and energy efficiency in Nevada. We acknowledge that these programs[286] have existed in Nevada, some over decades, and that our recommendations may coincide with the resurrection of some of these programs to further the clean energy transition within Nevada.

Recommendation 1: Continue programs, with appropriate funding, that offer cross-sector benefits and collaboration.

In Nevada, many projects and partnerships are funded through a combination of the legislatively created Nevada Renewable Energy Account and the US Department of Energy State Energy Program grant, providing for a broad range of opportunities to adopt renewable energy and energy efficiency measures while reducing energy waste.[287, 288] Projects span across the transportation, residential, commercial, education, and electricity generation sectors, and include funding mechanisms for other Office of Energy programs previously mentioned.

For example, funding was allocated to install and operate multiple charging stations, study existing policies for energy efficiency and savings, and create electrification strategies for the transportation sector from 2015 - 2018. Some government facilities in the commercial sector directly benefit from these funds and include battery storage in state-owned agencies and educational buildings, and retrofitting the lighting, HVAC, control systems for building efficiency. Transportation projects have included energy auditing for consumption and demand at electric vehicle charging stations with emphasis on the use of energy storage to reduce costs, electric bus deployment, and electric vehicle "ride and drive" testing stations for residents to test-drive and become more familiar with electric vehicle benefits. Educational outreach took a variety of forms, and after the Las Vegas branch of the Governor's Office of Energy opened in 2019, multiple stakeholder events were held there. Additional gatherings furthered energy discussions such as the (1) professional development and curriculum in the Project ReCharge: STEM Energy Education program targeting educators and students, and (2) several decarbonization workshops with multiple stakeholders including government entities (local, regional, and state agencies), and coalitions (such as the US Climate Alliance's Fall Convening), and (3) direct community workshops for residential zero-energy technologies that promote energy efficiency and new home construction. Funding towards renewable energy generation has focused on projects such as battery storage, solar programs for low-income populations, and increasing capacity in off-grid, remote, rural, or recreational areas.[289, 290]

Recommendation 2: Incentivize residential efficiency measures and electric vehicle adoption among households in underserved, underrepresented communities or with high combined energy cost burdens.

Total energy cost burdens—combined residential energy and vehicle fuel costs as a fraction of household income—generally increase as household income decreases, even though higher-income and White households tend to consume more energy and drive

286 Governor's Office of Energy. "Completed Programs." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/Completed_Programs/

287 Office of Energy Efficiency & Renewable Energy. "State Energy Program." *US Department of Energy*. Accessed Nov. 2020. Available at: https://www.energy.gov/eere/wipo/state-energy-program

288 Governor's Office of Energy. "Project Funding Partnerships.": *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/State_Energy_Program_Formula_Grant/

289 Governor's Office of Energy. 2019 Status of Energy Report. *State of Nevada* (2019).

290 Governor's Office of Energy. "List of Project Funding Partnerships." *State of Nevada.* Accessed Nov. 2020. Available at: https://energy.nv.gov/Programs/SEPFG_Archives/

more on average. Socioeconomic status and racial background are therefore important determinants of energy burden, and improved access to bill-reducing clean energy technology such as efficiency measures, community solar (particularly with virtual net metering[291]), and electric vehicles may help reduce traditionally marginalized households' energy burdens.

Based on our findings, low-income populations and communities of color are correlated with high vehicle fuel cost burden, and therefore these households should be targeted for clean energy adoption to maximize economic co-benefits; however, demographic indicators correlated with energy burden may vary geographically (**Figures 17** and **18**). Additionally, resilience and public health may be improved by targeting populations vulnerable to natural disasters (e.g. linguistically isolated communities), historic barriers to reliable and clean energy access (e.g. tribal communities), and populations with high pollution burdens (e.g. communities of color). Policy initiatives such as rebates and subsidies for clean energy adoption, among others, may reduce existing sociodemographic and geographic barriers to access. Residential electricity rates may also have to be restructured to ensure that electrification efforts—both for appliances and vehicles—do not shift consumers into a higher-cost electricity tier and inadvertently cause a disproportionate increase in electricity bills.

Recommendation 3: Prioritize pollution reduction measures—such as electrification, fuel switching, and brownfield remediation—in communities facing high cumulative environmental burdens across sectors; increase environmental data collection efforts to help identify these hotspots.

Energy pollution burdens, shown in **Figures 24** and **27**, reflect how racialized policy practices and income inequality impact pollution burdens in communities of color and low-income populations. There are several ways to address these pollution burden inequities. One measure is to better characterize pollution hotspots by increasing environmental monitoring in regions of concern, and conduct dispersion modeling of pollution reduction measures to identify high-impact emission reduction strategies. Though this report focuses on air quality, monitoring efforts should include various air, water, soil, and other environmental indicators as appropriate, and characterize their cumulative health impacts wherever possible. A second is to ensure facilities are regularly inspected and pollution emission standards enforced. A third is to prioritize, with community guidance, the replacement of remaining power generation (inclusive of small diesel generators) in hotspot areas with energy storage and/or renewables. A fourth is to target cross-sector pollutant reduction measures such as electrification of heavy-duty equipment at industrial facilities, electrification of trucks doing short-distance trips in industrial areas, re-routing trucks away from more residential areas, anti-idling truck regulations, and to continue to build-out electric vehicle charging infrastructure.

Additional cross-sector measures may include brownfield remediation and neighborhood greening efforts, such as tree planting which can have substantial benefits for local community environmental conditions. Indeed, in 2015, Reno joined the Global Covenant of Mayors on Climate and Energy and strongly pushed for tree canopy equitable distribution.[292]

Recommendation 4: Consider the distinct characteristics of rural and urban areas when designing decarbonization and energy equity policies.

Policies to address the clean energy transition must consider populations in both urban and rural areas. As our Demographic Index reveals, populations in both regions can have higher shares of traditionally marginalized communities (low-income, people of color, limited educational attainment, linguistically isolated, elderly, and very young populations). In urban cores, moderate- to lower-income neighborhoods are more racially diverse and have disproportionately higher energy burdens and pollution emission burdens, relative

291 Community solar with virtual net metering lets customers receive utility bill credits for using solar that is located off-site, which is particularly beneficial for multi-family and other residential building configurations that do not have the space or ownership rights to make permanent solar installation. This community solar approach has been shown to be beneficial for fixed and reduced utility rates (typically below the retail utility rate), which stabilizes more affordable electricity access for populations that are rate sensitive, or those who have limited ability to make permanent energy efficiency upgrades such as tenants. However, this has been tried previously in Nevada unsuccessfully.

292 Barker, Lynne *et al.* City of Reno Sustainability & Climate Action Plan 2019-2025 (2019).

to the rest of their respective metropolitan area, further perpetuating the negative externalities from racially motivated redlining in housing and historic exclusionary practices in employment, education, and job training for communities of color.[293,294] We also find that many of these communities face high cumulative environmental burdens from existing fossil fuel infrastructure and transportation emissions, which are modeled to take longer to electrify than other sectors.

Our findings reveal that rural communities (and likely tribal communities based on the very limited accessible data) also face multiple challenges, including the persistence of $PM_{2.5}$ pollution due to indoor air pollution from higher wood burning, persistent exposure to pollutants associated with mining production, and higher risks of the compounding effects of extreme heat days, wildfire risk, and higher energy cost burdens, as shown in **Figure 33**. Rural and tribal communities that are moderate- to low-income also face burdens of lack of consistent access to energy, or no connectivity at all. Rural areas have high concentrations of White Nevadans compared to urban areas. Even so, there are Native American and Hispanic/Latin populations clustered in Nevada's rural western and northeastern regions, as well as populations of color dispersed throughout rural Nevada.

Recommendation 5: Restructure clean energy financing mechanisms to enable equitable access to capital among economically vulnerable communities.

Lack of access to capital is a large hindrance for clean energy technology adoption among overburdened and underserved racially- and socioeconomically-disadvantaged populations. To avoid inequitable adoption rates similar to solar, which are heavily skewed towards higher-income populations and White populations based on national trends,[295] assessment should be taken to identify Nevadans who lack access to financial capital or experience non-financial barriers for clean energy conversions. Inequities in clean energy access can be reduced, in part, through renewable energy, efficiency, and electrification financing mechanisms supporting underrepresented and underserved households—such as point-of-purchase rebates and low-interest loans—rather than relying on tax incentives and post-purchase rebates.

Broader measures to support equitable access to clean energy and benefits from the clean energy economy, which may be already be underway in local communities in Nevada, should also include, at-large:

- Financing of education for clean energy career advancement for non-graduates, new-graduates, and non-energy career professionals to transition;
- Research funding to identify, and address, financial and non-financial barriers to access clean energy for historically marginalized communities, particularly communities of color, who face higher average financial burdens than White communities regardless of income status;
- Community engagement reimbursement and stipend funding for participants, to assure community members are not adversely affected financially by participating in the engagement process;
- Continued widespread public infrastructure investments for electric vehicle charging stations, conversion/retrofitting of current fueling stations, and electric grid upgrades to support distributed energy resources;
- Financial incentives for communities of color and underserved populations to access clean energy technologies, encompassing the sector-specific recommendations described earlier;
- Support for businesses repurposing, recycling, or dismantling renewable energy technologies used in the clean energy transition for safe disposal at end-of-life, coupled with financing for transitioning current fossil fuel-focused companies that perform end-of-life services to the new opportunities in the clean energy economy.

Financing mechanisms and related efforts should be accompanied by further workforce development, for which a detailed analysis is beyond the scope of this study. However, a key consideration should include skilled job training in clean energy fields focused on current fossil fuel industry workers.

293 Rice, Solana. Ever-Growing Racial Wealth Gap & What It Means for Nevada. *CFED*, (2017).

294 Hunt, Jerome. A State-by-State Examination of Nondiscrimination Laws and Policies. *Center for American Progress Action Fund* (2012).

295 Sunter, Deborah,*et al.* Disparities in Rooftop Photovoltaics Deployment in the United States by Race and Ethnicity. *Nature Sustainability* 2.1 (2019): 71-76.

3.4 Recommendations for Future Research and Data Needs

3.4.1 Data Collection Needs Moving Forward

Much of our analysis is based on models and estimates due to lack of granular pollution, emission, and energy use data. Data collection in the areas below would be very valuable to better identify communities and sectors for energy investments and pollution reduction, set health-protecting regulations, enable better enforcement, and create a baseline upon which to measure success. With the exception of some data that should be aggregated to protect individual privacy, these data should be publicly available, easily accessible, transparent, and regularly updated.

Cross-Sector

Air Quality

1. High-density ambient air monitoring, particularly in potential pollution hotspots.
2. Fenceline air monitors at power plants and industrial facilities, including for hazardous air pollutants such as benzene, toluene, ethylbenzene, and xylene.
3. Indoor air monitoring and exposure assessment characterizing concentrations of and exposure to pollutants associated with in-home fossil fuel and biomass use.

Electricity Access

1. Historical and contemporary electricity accessibility and reliability data within the state, by census tract. This should be updated regularly and broken down by sociodemographic indicators, and include community surveys or other self-reporting mechanisms to more broadly capture all populations.
2. Electricity access data for tribal populations.
3. Reliability data by utility provider and consumer.
4. Adoption rates and availability of capital financing for distributed electricity resources (i.e. solar, energy storage, etc.) specific to Nevada.

Transportation

1. Traffic data for Nevada from the Federal Highway Administration's (FHWA) 2018 HPMS dataset only provides a breakdown by three vehicle categories: 1) all vehicles, 2) single-unit heavy duty trucks, and 3) combination-unit heavy duty trucks.
2. To improve the granularity of our data by vehicle class, we used national estimates of the vehicle miles traveled breakdown by vehicle class and highway category from the FHWA 2018 HPMS VM-1 table. Traffic data with a more granular breakdown by vehicle class for each functional classification in Nevada would improve the accuracy of vehicle emissions estimates.
3. We recommend that Nevada submit traffic data for local roads (HPMS Functional Classification 7) voluntarily to the FHWA HPMS, along with required Functional Classifications 1-6.
4. Accessible data on average idling times for light-duty, medium-duty, and heavy-duty trucks in Nevada would allow for more accurate on-road vehicle emission estimates.
5. Data on electric vehicle adoption is only available by county in Nevada, and cannot be accessed electronically through the Nevada Department of Motor Vehicles. Data at a more spatially granular level, as is provided for a number of other states through the Atlas Public Policy EV Hub, would allow for analysis of the socioeconomic and demographic characteristics of electric vehicle adoption.
6. NEI data on nonroad mobile source emissions are only available at the county-level. Data at a more spatially granular level would allow for public health and equity analyses.

Power

1. Primary particulate matter emissions measured hourly (rather than estimated) and covering all facilities.
2. Current and regularly updated data on the ownership for fossil fuel facilities and clean energy facilities, along with sociodemographic breakdown of ownership, board, and leadership positions.

Residential Buildings

1. Household-level energy use and burden data, aggregated at the census tract or block group level to protect privacy while allowing some spatially refined analysis.
2. Energy efficiency and solar adoption rates by household, again summarized for individual household privacy.
3. Gas distribution line and service area data. We identified State[296] and Federal[297] data sources which did not match. Given the public safety hazards inherent in natural gas distribution and the potential for these hazards to increase if systems are not retired properly, it is important to know the exact alignment of distribution systems and who is responsible for their maintenance in any given area.

296 Nevada Public Utilities Commission. "Utility Service Area Maps." Accessed: Nov. 2020. Available at: http://puc.nv.gov/Utilities/Utility_Service_Area_Maps/

297 US Department of Homeland Security. "Natural Gas Service Territories." Accessed: Oct. 2020. Available at: https://hifld-geoplatform.opendata.arcgis.com/datasets/natural-gas-service-territories

Commercial Buildings

1. Spatially detailed emissions data (e.g. city or county level) collected and maintained by the government.
2. Fuel-use emissions reporting requirements categorized by commercial use (e.g. retail, hotels, salons, casinos, etc.) and occupancy.

Fuel-use emissions reporting requirements based on building type (e.g. Class A, B, or C[298]), and location in accordance with a standards organization such as NAIOP[299] or CoStar.[300]

Industry

1. While the National Emissions Inventory (NEI) provides criteria air pollutant emissions data for industrial point sources, the data do not adequately distinguish between combustion and non-combustion emissions at the facility-level. More detailed facility-level emissions data would allow for analysis of the impact of decarbonization on the spatial distribution of industrial emissions.

3.4.2 Recommendations for Research

Baseline Environmental Justice Screening Data

We created a Demographic Index and an Environmental Index, reliant on EJSCREEN indicators, to identify socioeconomically and environmentally burdened populations across Nevada. However, it may be valuable for the state to design its own environmental justice screening tool using indicators which reflect Nevada's priorities and needs to support vulnerable and environmentally overburdened populations. In addition to identifying a suite of socioeconomic indicators deemed pertinent by Nevada stakeholders, this tool could incorporate additional indicators such as health measures (e.g. asthma rates) and environmental burdens (e.g. pesticide concentrations). Input from a broad range of stakeholders, including scientists, community organizations, and others, can provide valuable insights into the design of such a screening tool. The resulting tool may be useful for designing energy and climate policy and measuring its effectiveness, and also applied to policy decisions more broadly.

Health Impacts Analyses

Our analysis here focuses primarily on current pollutant emissions and changes in emissions under different decarbonization scenarios in order to determine whether or not there are inequities in pollution burdens and to identify potential strategies to alleviate those burdens. However, we did not assess exposures or model the health impacts of these emissions. The trends in pollutant emissions we have identified suggest there may be disparities in environmentally mediated health outcomes due to the uneven spatial distribution of fossil infrastructure and inequities in pollution mitigation pathways. These findings highlight the need to model air pollution dispersion and health impacts for any proposed state decarbonization policies in order to achieve greater health benefits for communities across Nevada, particularly those burdened by a disproportionate share of pollution. For example, Fann *et al.* (2011) illustrate strategies to maximize health benefits and reduce inequality in pollution burdens by focusing on multi-pollutant reductions in vulnerable communities.[301]

298 Commercial building classifications vary by organization and other external factors. In general Class A represents the highest grade or quality available, as compared to Class B, C, etc.

299 Originally founded as the National Association for Industrial and Office Parks, this trade and standards organization currently operates as the Commercial Real Estate Development Association. https://www.naiop.org/ Last accessed Oct. 2020.

300 CoStar. "CoStar Building Rating System." Accessed Oct. 2020. Available at: https://www.costar.com/docs/default-source/brs-lib/costar_buildingratingsystem-definition.pdf?sfvrsn=12a507a4_2

301 Fann, Neal, *et al.* Maximizing Health Benefits and Minimizing Inequality: Incorporating Local-Scale Data in the Design and Evaluation of Air Quality Policies. *Risk Analysis: An International Journal* 31.6 (2011): 908-922.

Our initial screen highlights sectors and regions where a detailed health impact analysis of both the current system and of clean energy policy strategies may be valuable. These include both indoor and outdoor air quality analyses, such as quantitative research on exposures to indoor air pollution from natural gas leakage to better characterize health risks associated with residential natural gas use. Though exposure and health impact assessments may further our understanding of the equity dimensions of decarbonization and provide valuable, Nevada-specific data, the desire for additional study should not preclude or delay policy action[302] towards equitable decarbonization, particularly in light of the well-established body of literature documenting adverse health outcomes among communities near fossil fuel infrastructure.[303,304]

Managed Retirement of Infrastructure

We see a significant risk of inequitable utility bill impacts moving forward for households that do not electrify. One strategy to limit these impacts would be selective "pruning" of the natural gas infrastructure, effectively electrifying entire neighborhoods at a time and retiring the gas distribution lines to reduce upkeep costs. This should be accompanied by fully funding environmental remediation costs, to minimize undue financial burdens on local communities where retiring facilities are sited. Further, it would be valuable to analyze the gas loads and strategies that would allow for such a transition to minimize infrastructure upkeep costs. During this transition period, publicly funded financial mechanisms can be used to stabilize ratepayer utility bills, and reduce them for energy cost overburdened customers.

Barriers to Clean Energy Adoption

Current trends suggest that solar, storage, efficiency, and vehicles are inequitably distributed across Nevada. To mitigate these inequities moving forward, while acknowledging the historic and current social inequities that exist in the state, the State should collect higher-granularity data on existing adoption rates and analyze these in relation to existing demographic and socioeconomic distributions in order to set a reliable baseline. Additionally, this research should specifically address the procedural inequities that may exist in current policies by evaluating to what degree increased local control and community engagement of energy decision-making leads to improved and inclusive processes and policy outcomes in NV, by measuring economic and environmental benefits by demographic and socioeconomic indicators.

The state should conduct a study, using analysis techniques and methods from environmental, public health, and social science fields, to identify specific barriers facing clean energy adoption, including but not limited to:

- Quantifying the level or omission of community engagement in all energy equity, renewable energy, and energy efficiency policies and programs;
- Quantifying the level of stakeholder engagement required for each policy, including the demographic and socioeconomic indicators of stakeholders;
- Measuring the efficacy of community engagement, as it relates to socially and environmentally equitable outcomes, in current policies and programs.

In order to design effective policies, ongoing data collection is necessary to allow for ongoing comparison to the baseline adoption levels and provide opportunities to revise policies equitably, as needed.

302 Savitz, David. Response to Environmental Pollution: More Research May Not Be Needed. *Epidemiology* 27 (2016): 919-920.

303 Lelieveld, Jos, *et al.* "The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale." *Nature* 525.7569 (2015): 367-371.

304 Brender, Jean D., *et al*. "Residential Proximity to Environmental Hazards and Adverse Health Outcomes." *American Journal of Public Health* 101.S1 (2011): S37-S52.

4. Technical Appendix: Methods

4.1 Overview of Methods

We used a three-step process to identify priority areas for the State of Nevada to build energy equity and co-pollutant reduction benefits into its decarbonization strategy. First, we approximated sectoral greenhouse gas and criteria pollutant emissions at fine spatial resolution. To do so, we applied emissions factors to energy production and consumption data obtained using processes detailed in the sector-specific methods below. Next, we joined these data with demographic data from the US Census Bureau. This enabled us to characterize the state's existing energy equity landscape—accounting for such considerations as clean energy access, bill burdens, and proximity to pollution, among others. We then integrated our findings from the first two steps with Evolved Energy Research's model results to illustrate how various decarbonization pathways may be implemented in a manner which maximizes social and environmental co-benefits. Throughout this process, we held multiple listening sessions and interviews with Colorado community organizations to understand their energy equity and social equity priorities for their local communities. Methodologies and source data used at each step are discussed in greater detail below.

4.2 Sectoral Energy Equity and Emissions Mapping

4.2.1 Baseline Demographic and Environmental Indicators

We analyzed population characteristics and cumulative environmental burdens across Nevada using a mix of data aggregated from the US Census and from the US Environmental Protection Agency's environmental justice screening tool EJSCREEN.[305] EJSCREEN includes census block group information on a set of demographic indicators, including:[306]

Demographic indicators

1. **Populations of color:** Population fraction that is not non-Hispanic White;
2. **Low-income:** Population in households below double the federal poverty level;
3. **Linguistic isolation:** Population living in households where no one over the age of 14 speaks English as a primary language and all adults speak English less than "very well;"
4. **Educational attainment:** Fraction of adults aged 25 and over, with less than high school education;
5. **Children:** Population fraction under age five;
6. **Elderly:** Population fraction over 64.

305 US Environmental Protection Agency. "EJSCREEN: Environmental Justice Screening and Mapping Tool." Available at: www.epa.gov/ejscreen

306 Descriptions and data years for EJSCREEN indicators are provided in the "Technical Documentation for EJSCREEN." Available at: www.epa.gov/ejscreen/technical-documentation-ejscreen

Environmental indicators

1. **NATA cancer risk:** Cancer risk from air toxics;
2. **NATA respiratory hazard index:** Respiratory hazard index from air toxics;
3. **NATA diesel PM:** Diesel particulate matter concentrations;
4. **Particulate matter:** Average annual $PM_{2.5}$ concentrations;
5. **Ozone:** Average of summer daily eight-hour maximum ozone concentrations;
6. **Traffic proximity:** Vehicle count at major roads within 500 meters, normalized by distance;
7. **Lead paint:** Percent of buildings built before 1960;
8. **Risk Management Plan sites:** Count of facilities with chemical accident plans within 5 km, normalized by distance;
9. **Hazardous waste facilities:** Count of hazardous waste facilities (treatment, storage, and disposal facilities) within 5 km, normalized by distance;
10. **Superfund sites:** Count of national priorities list sites within 5 km, normalized by distance;
11. **Wastewater discharge indicator:** Risk-screening environmental indicators: toxics concentrations in stream segments within 500 meters, normalized by distance.

Census tract-level values were calculated for each indicator using the population-weighted average of the block group values in each tract. This calculation is expected to be accurate for demographic indicators and certain environmental indicators (e.g. the spatial granularity of EJSCREEN's ozone data is not at the block group level, so every block group in a tract reported identical values), but it leads to an approximation for some environmental indicators. The indicator value for each census tract was then compared to the remaining census tracts statewide and assigned a percentile value.

To identify populations which are either a) overburdened with numerous sources of environmental pollution or b) uniquely vulnerable to this pollution due to cumulative socioeconomic burdens, we created a set of indices to reflect a combination of demographic and environmental indicators as follows:

1. **Demographic Index:** The raw value for the Demographic Index was calculated by averaging the percentiles for each of the above demographic indicators. This raw value was then assigned a statewide percentile by comparing census tracts across the state, and the percentile value used as the Demographic Index score.
2. **Environmental Index:** The raw value for the Environmental Index was calculated by averaging the percentiles for each of the above environmental indicators. This raw value was then assigned a statewide percentile by comparing census tracts across the state, and the percentile value used as the Environmental Index score.

This index is necessarily limited by the data available within EJSCREEN. We therefore also assess some of our data in the context of additional environmental and socioeconomic indicators not available in EJSCREEN. These include the following, reflecting additional environmental burdens, climate vulnerabilities, and health vulnerabilities:

1. **Non attainment areas:** Regions that exceed federal air quality standards (in this case, average 8-hour ozone concentrations) in the US Environmental Protection Agency's Green Book.[307]
2. **Wildfire risk zones:** Regions facing high wildfire risk.[308]
3. **Projected extreme heat days:** Number of days projected to exceed 95° F given a moderate carbon emissions scenario in the 2020-2039 timeframe.[309]

307 US Environmental Protection Agency. "Nevada 8-hour Ozone Nonattainment Areas (2015 Standard)." Available at: www3.epa.gov/airquality/greenbook/nv8_2015.html

308 Colorado State Forest Service. "Wildfire risk viewer." Available at: https://coloradoforestatlas.org/

309 Kopp, Robert and Rhodium Group. "Probability-weighted ensembles of U.S. county-level climate projections for climate risk analysis." July 2016. Accessed: Dec. 2020. Available at: https://rucore.libraries.rutgers.edu/rutgers-lib/49865/

We used these indicators to assess both their combined and individual relationships with energy burdens and cumulative environmental burdens from the fossil fuel industry, as described below. These indicators are meant to help characterize both cumulative burdens and vulnerabilities, but are not necessarily complete, and the state may choose to include additional indicators (e.g. health measures such as low birthweight births and environmental exposure metrics such as proximity to pesticide application) for decision-making purposes.

4.2.2 Power Sector

We aggregated power plants from the US Energy Information Administration's Form 860[310] and selected a subset of 55 facilities burning fossil fuels (including natural gas, petroleum liquids, and coal) and/or biofuels (including landfill gas and wood), seven of which were deemed likely idle or closed. We cross-checked and updated facility locations using satellite view on Google Maps.[311]

We subsequently characterized populations in close proximity to Colorado's power plants by calculating population characteristics within a one-mile and three-mile radius of each plant. We used 2010 Census Block data[312] for population weighting and 2014-2018 Census Block Group data[313] to obtain underlying population characteristics such as population size, percent of residents under two times the Federal poverty line, and percent non-white residents. Our methods are modeled after the Environmental Protection Agency's EJSCREEN population weighting methods, which are described in the tool's technical documentation.[314]

We used the US Environmental Protection Agency Air Markets Program Database[315] for 2019 to calculate baseline emission data, including total CO_2, SO_2, and NO_x emissions and rates of emissions per megawatt-hour of electricity generation. This database omits some small and infrequently used power plants. We cross-checked the generation and emissions for these small facilities for 2018, which are estimated by the US Energy Information Administration,[316] and determined they account for roughly 1 percent of in-state fossil fuel and biomass-consuming power generation. The estimated emission rates of NO_x and SO_2 from some of these facilities seemed anomalously high. We therefore included these facilities (which may be small but often burn high-emission fuels like diesel) in our analysis of populations near power plants, but only included the data for plants for which we have measured emissions in our analysis of electricity transition pathways.

We used the emission rates calculated above to estimate the average emissions of each power sector generation scenario developed by Evolved. We next calculated how much emission benefit could be obtained by prioritizing the retirement of plants with the highest co-pollutant emission rates. We ranked the plants by emission rates, and assumed that the highest-emission plants would be retired first (including the highest SO_2 emission rates for coal plants and the highest NO_x emission rates for natural gas plants). Using this prioritization, we compared end-point (e.g. 2030) and cumulative emissions from each scenario with and without prioritizing retirement of higher polluting facilities.

310 US Energy Information Administration. "Form EIA-860 (2018)." 2020. Available at: www.eia.gov/electricity/data/eia860

311 Google. "Maps." 2020. Available at: www.google.com/maps

312 US Census Bureau. "TIGER/Line FTP Archive: TIGER2010BLKPOPHU." June 2011. Available at: www2.census.gov/geo/tiger/TIGER2010BLKPOPHU/

313 US Census Bureau. "TIGER/Line FTP Archive: 2018 ACS." April 2020. Available at: www2.census.gov/geo/tiger/TIGER_DP/2018ACS/

314 US Environmental Protection Agency. "EJSCREEN Technical Documentation." Sept. 2019. Available at: www.epa.gov/sites/production/files/2017-09/documents/2017_ejscreen_technical_document.pdf

315 US Environmental Protection Agency. "Air Markets Program Data." 2020. Available at: https://ampd.epa.gov/ampd/

316 US Energy Information Administration. "Emissions by plant and by region." 2020. Available at: www.eia.gov/electricity/data/emissions/

4.2.3 Transportation

On-Road Mobile Source Emissions

Using the Federal Highway Administration's 2018 Highway Performance Monitoring System (HPMS) dataset, we multiplied annual average daily traffic by road segment length to obtain daily vehicle miles traveled (VMT) for each road segment. The HPMS dataset provides annual average daily traffic data for three categories: (1) all vehicle categories, (2) single-unit heavy-duty trucks, and (3) combination-unit heavy-duty trucks.

To obtain a more granular breakdown of VMT, we used national estimates from the 2018 HPMS VM-1 Table on the VMT breakdown by vehicle category, highway category, and rural/urban designation. We applied the national VMT breakdown to the HPMS road segment vehicle miles traveled data in order to estimate a breakdown of VMT by the following HPMS vehicle categories: (1) motorcycles, (2) light-duty passenger cars, (3) light-duty trucks, (4) buses, (5) single-unit heavy-duty trucks, and (6) combination-unit heavy-duty trucks.

We created a 250-foot buffer around each road segment in the HPMS dataset and proportionally allocated VMT to overlapping census tracts based on area of overlap. We subsequently aggregated VMT across road segments within each census tract to estimate total VMT for each census tract. This procedure was carried out for each HPMS vehicle category to enable later application of emissions factors.

To estimate criteria air pollutant emissions in each census tract, we used EPA MOVES 2014a state-specific emission factors for carbon monoxide, NO_x, $PM_{2.5}$, PM_{10}, and VOCs, which are provided for each vehicle model year. We used Evolved's assumed allocation of VMT by vehicle vintage for each analysis year to calculate a fleet-average emission factor for each MOVES vehicle source type and fuel type (gasoline and diesel). Rather than project emission factors for vehicle model years 2020-2050, we used 2019 emission factors for the equivalent vehicle type. Due to missing emission factors for gasoline-powered long-haul single-unit heavy-duty trucks, we used emission factors for gasoline-powered short-haul single-unit heavy-duty trucks for that MOVES vehicle source type. For alternative fuel vehicle types used in Evolved's model, we used emission factors from Argonne National Laboratory's 2019 AFLEET tool.

We applied emission factors (grams/mile) to statewide VMT for each vehicle category, mapping the MOVES vehicle source types to their corresponding HPMS vehicle categories. When multiple MOVES vehicle source types mapped to one HPMS vehicle category (e.g. buses), we averaged the emission factors across MOVES vehicle source types within the corresponding HPMS vehicle category.

We assigned a weight to each census tract based on its fraction of statewide VMT for each vehicle category. We then allocated emissions by pollutant and HPMS vehicle category to each census tract by multiplying the tract's weight by the statewide emissions from that HPMS vehicle category.

To analyze criteria air pollutant emissions over time for each decarbonization scenario, we used the Evolved model's projected changes in VMT and fuel switching for each vehicle category. We assumed the relative contribution of each census tract to statewide VMT per vehicle category remained the same from 2017-2050 despite changes to overall statewide VMT. We also assumed that fuel switching occurred uniformly (geographically) across the vehicle fleet for each vehicle category.

Transportation Fuel Burden

To estimate the fraction of VMT that is household-generated (i.e. not from commerce), we took the national sum of household travel from the 2017 National Household Travel Survey and divided it by the national sum of light-duty VMT from the 2017 Federal Highway Administration HPMS dataset. We applied the resulting household travel fraction of light-duty VMT of approximately 73 percent to Evolved Energy's projected statewide light-duty VMT for every year from 2017-2050 to project annual household-generated VMT. We attributed this resulting statewide estimate solely to passenger cars and light-duty passenger trucks, excluding light-duty commercial trucks. We excluded motorcycles, as Evolved did not estimate VMT for this vehicle class. We then derived the fuel use for household-generated light-duty vehicle travel, using Evolved's fuel use estimates for passenger cars and light passenger trucks.

To allocate household travel fuel use to each census tract, we used the Bureau of Transportation Statistics 2017 Local Area Transportation Characteristics for Households data on average household weekday travel by census tract. We multiplied the average household weekday travel by the count of households with vehicles in each census tract to estimate aggregated household weekday travel for each census tract. We then assigned a weight to each census tract based on its proportional contribution to total statewide household weekday travel. We then multiplied each census tract's weight by the statewide household travel light-duty vehicle fuel use estimated above to estimate household travel fuel use for each census tract.

To estimate household fuel costs associated with vehicle travel, we multiplied tract-level aggregated household fuel use by Evolved's baseline and projected fuel costs by fuel type. We used Evolved's 2020 fuel costs for the baseline 2017 transportation fuel burden estimates. We then divided the total tract-level fuel costs by the number of households in each census tract to estimate transportation fuel cost for the average household in each census tract. We divided this by median household income from the American Community Survey 5-year 2014-2018 dataset to estimate annual transportation fuel burden as a fraction of income for the average household in each census tract.

Electric Vehicle Charging Stations

We used data from the Department of Energy's Alternative Fuels Data Center to visualize the location of public electric vehicle charging stations and the density of electric vehicle supply equipment (EVSE), or charging outlets, in Nevada. We include AC Level 2 and DC fast charging stations. To estimate the rate of EVSE per 100,000 people in Nevada, we summed EVSE across all public charging stations and divided by the state population (divided by 100,000).

4.2.4 Residential Buildings

Residential energy consumption data are not readily available at geographic scales conducive to spatial or demographic analysis—though reliable statewide estimates by fuel type are available from the Energy Information Administration.[317] We accordingly built a regression model to develop weights which apportion statewide residential energy consumption to individual census tracts based on a variety of geographic, climatic, housing-related and demographic variables.

Our model uses previously developed methods[318,319] to estimate each tract's relative contribution to statewide residential electricity, natural gas, propane, and wood consumption. Predictive variables for each census tract were extracted from the 2015 Residential Energy Consumption Survey[320] and the 2014-2018 American Community Survey[321] to estimate fuel-specific energy consumption for the average household in each census tract. We used this output, supplemented with additional electricity and natural gas data (provided by the authors of Min et al. 2010 and updated with more current predictors),[322] and the number of households in each tract to develop a weighting factor for each tract's share of statewide energy consumption.

We then applied this weighting factor to the Energy Information Administration's statewide consumption estimates to approximate each tract's residential energy consumption by fuel. These weighted values were used as baseline census tract energy consumption estimates. Similarly, we applied these weighting factors to projected consumption estimates under each Evolved scenario to estimate future census tract-level residential energy consumption along each modeled decarbonization pathway. This methodology assumes the distribution of energy consumption amongst census tracts stays constant, and does not account for any changes to its spatial distribution between different

317 US Energy Information Administration. "State Energy Data System." Available at: https://www.eia.gov/state/seds/

318 Jihoon Min *et al*. A High-Resolution Statistical Model of Residential Energy End Use Characteristics for the United States. *Journal of Industrial Ecology* 14.5 (2010): 791-807.

319 Christopher Jones and Daniel M. Kammen. Spatial Distribution of US Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density. *Environmental Science & Technology* 48.2 (2014): 895-902.

320 US Energy Information Administration. "Residential Energy Consumption Survey 2015." Available at: https://www.eia.gov/consumption/residential/data/2015/

321 US Census Bureau. "TIGER/Line FTP Archive: 2018 ACS." April 2020. *Ibid.*

322 Jihoon Min *et al*. A High-Resolution Statistical Model of Residential Energy End Use Characteristics for the United States. *Journal of Industrial Ecology* 14.5 (2010): 791-807.

scenarios. We subsequently multiplied all tract-level energy consumption estimates by emission factors[323] to identify priority areas for greenhouse gas reductions, populations and geographic regions likely to use more heavily polluting fuels, and possible changes in the distribution of residential emissions for different decarbonization pathways.

Residential Energy Cost Burden

To characterize baseline residential energy cost burdens, we multiplied our census tract-level energy consumption estimates by 2018 Energy Information Administration Nevada prices by fuel.[324] We used the same methodology to project energy cost burdens with 2030 tract-level consumption estimates and scenario price projections from the Evolved model. Average household energy cost burden was then calculated for each census tract by dividing estimated energy expenditures by household income.

Residential Bill Impacts

To illustrate the impacts of fuel switching and energy efficiency measures on household energy bills, we used Evolved projections for residential fuel consumption, fuel prices, and clean energy adoption rates to calculate the average increase in household electricity use under each Evolved scenario relative to the Reference case. We then attributed the electricity use increase to the fraction of adopting households only and eliminated these households' natural gas bills. Non-electrifying households were assumed to have the same average electricity and natural gas consumption as in the Reference scenario.

The Evolved model assumes different electrification rates for different residential end-uses. We used the projected electrification rates for space heating as a proxy for all electrification measures with the assumption that they happen simultaneously to simplify our calculations. Because the Low Demand, Core, and Fossil Free scenarios all have identical residential end-use electrification rates in the Evolved model, we also incorporated the rate of residential building shell retrofits to distinguish the Low Demand scenario, which has higher rates of energy efficiency upgrades, from the other scenarios.

The goal of the outlined approach to calculating residential bill impacts was to provide an illustrative comparison between clean energy adopter and non-adopters' bills, and between the different scenarios based on projected fuel consumption, fuel prices, and adoption rates, all other things being equal.

Residential Solar Deployment

We applied the weights calculated as described in **Section 4.2.4** to statewide 2030 residential energy consumption estimates for Evolved's Core scenario. We additionally developed census tract population weights by dividing each tract's baseline number of people and households by statewide totals. We multiplied these weights by 2030 values from the Evolved model to get tract-level demographic projections.

We joined our tract-level energy and population projections with data describing potential high-priority populations for residential solar deployment. Populations identified as high-priority include those who may derive additional resilience, economic, and/or health benefits from rooftop solar deployment, such as residents of counties with a high number of projected mid-century heat days,[325] households with income below the Federal poverty line,[326] rural households,[327] and households with at least one person dependent on electricity for medical reasons.[328]

323 California Air Resources Board, "Residential Emissions Factors". Available at: https://ww2.arb.ca.gov/carb-miscellaneous-process-methodologies-residential-fuel-combustion; Environmental Protection Agency "Residential Emission Factors". Available at: https://www3.epa.gov/ttn/chief/ap42/ch01/index.html

324 US Energy Information Administration. "Residential Sector Energy Price and Expenditure Estimates, 1970-2018, Nevada." (2020). Available at: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_prices/res/pr_res_NV.html&sid=NV

325 Rasmussen, D. J. *et al.* "Probability-Weighted Ensembles of U.S. County-Level Climate Projections for Climate Risk Analysis." Rutgers University Libraries. 2016. Available at: https://rucore.libraries.rutgers.edu/rutgers-lib/51860/#package

326 US Census Bureau. "TIGER/Line FTP Archive: 2018 ACS." *Ibid.*

327 US Census Bureau. "TIGER/Line FTP Archive: 2018 ACS." *Ibid.*

328 US Department of Health and Human Services. "HHS emPOWER Map 3.0." Accessed Sept. 2020. Available at: https://empowermap.hhs.gov/

We used our demographic and consumption projections and a 0.22 average capacity factor for distributed solar in Nevada to estimate the solar capacity needed to match target populations' residential energy needs by 2030. We compared these numbers to the 2030 total solar and rooftop solar projections underlying Evolved's model outputs to gauge whether additional solar deployment or redistribution of solar resources (i.e. residential instead of commercial) might be considered to maximize co-benefits.

4.2.5 Commercial Buildings

To our knowledge, the most spatially granular commercial emissions data available to the public are delivered at the county level in the NEI.[329] Methods to derive more spatially detailed emissions data are not readily available for the commercial sector due to a lack of geographic and descriptive data such as those used to derive weighting factors for the transportation and residential sectors. As such, our analysis of the commercial sector and cross-sectoral analyses integrating commercial data are limited to the county level. Furthermore, data quality issues in the NEI commercial dataset lead us to conclude that these data are incomplete; and our commercial analyses are accordingly limited.

4.2.6 Industrial Sector

To evaluate current industrial criteria air pollutant emissions, we drew from the NEI 2017 point source dataset, excluding power plants and transportation-related point sources (airports, railyards), and the NEI industrial nonpoint source dataset, including only emissions from industrial fuel combustion and those distributed sources associated with the oil and gas sector. While the NEI nonpoint source dataset specifies which nonpoint sources are associated with oil and gas development, emissions are estimated at the county level and the locations of distributed sources are not provided.

While the NEI point source dataset provides criteria air pollutant emissions by industrial facility, it does not provide emission factors or EPA source classification codes for specific processes at these facilities. Without emission factors, we were unable to project criteria air pollutant emissions over time based on Evolved's projected changes in fuel consumption and production quantities for various industrial subsectors. Instead, we analyzed the spatial distribution of criteria air pollutant emissions from industrial point sources and compared baseline and projected fuel use across industrial facilities from Evolved's model.

4.2.7 Cross-Sectoral Data

In addition to analyzing the health, equity, and environmental implications of decarbonizing each individual sector, we sought to characterize economy-wide patterns by conducting cross-sectoral analyses. We joined the commercial, industrial, power, residential, and transportation data discussed in **Sections 2.2** to **2.6** above at the county level. Analyses at finer spatial resolution such as the census tract level were considered but omitted due to the lack of readily available commercial data below the county level and due to the complex nature of pollutant dispersion from point sources such as power plants and industrial facilities, which is outside the scope of this report.

Aggregate cross-sector datasets were used to analyze patterns such as overall baseline pollution distribution and household energy (residential) and fuel (transportation) burdens. Additional datasets pertinent to pollution and demographics were integrated into these analyses to provide further context. These include spatial data detailing the distribution of ambient air pollutant non-attainment areas.[330]

329 US Environmental Protection Agency. "National Emissions Inventory 2017 - Nonpoint Sources." Available at: https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei

330 US Environmental Protection Agency. "Green Book GIS Download." May 30, 2020. Available at: https://www.epa.gov/green-book/green-book-gis-download

4.3 Community Organization Outreach for Equity Considerations

We conducted multiple virtual listening and interview sessions with various Nevada organizations throughout 2020 in order to understand their policy, energy equity, and social equity concerns and priorities. In addition, relevant content and input from sessions for Colorado and New Mexico, the two other states included in the larger tri-state study, were also included in this Nevada study when there were broad interstate benefits for socioeconomically or geographically vulnerable populations. Some covered topics included local community priorities regarding:

- **Public health and policy priorities related to energy;**
- **Pollution sources and nearby communities;**
- **Economic impacts and job creation, stagnation, or decline;**
- **Local, community input and accountability of projects to communities;**
- **Access and funding to demand-side energy use reduction efforts, such as appliance efficiency;**
- **Access and funding to electrification efforts in transportation and housing.**

From these discussions, we compiled a list of focus areas and case studies that were incorporated into the technical analysis performed in this study.