Executive Summary

The Clean Power Plan provides Ohio with an opportunity to achieve public health and environmental justice benefits across the state, while simultaneously reaching its carbon emission reduction goals in the power sector. In this report, we analyze the health, environmental, and equity dimensions of power plants affected by the Clean Power Plan. We first assess the socioeconomic and environmental public health burdens for populations living near these plants. We then model the public health impacts of particulate matter attributable to fossil fuel combustion at Ohio's power plants. Our findings point to where carbon emission reductions may have the greatest public health benefits, and help to identify where changes in power generation may add to or alleviate health burdens on vulnerable communities.

The Clean Power Plan is a regulation issued by the Environmental Protection Agency (EPA) in accordance with the legal requirements of section 111(d) of the Clean Air Act. It sets carbon emission reduction targets for the power sector in order to mitigate the impact of electricity generation on climate change. Compliance with these objectives can yield significant public health and environmental justice co-benefits in addition to the climate benefits of the rule. However, both the scale of these benefits, and their geographic and demographic distribution, may vary widely depending on the manner in which the standards are implemented in each state.

Fossil fuel power generation is associated with numerous environmental health burdens that, historically, disproportionately affect vulnerable and already overburdened communities. Power plants are often located near low income and minority populations. These communities are more likely to experience a cumulative burden of multiple socioeconomic and environmental stressors, such as poor air quality and proximity to hazardous waste facilities. Residents in these areas are also likely to be more susceptible to adverse health outcomes when exposed to pollutants from fossil fuel combustion. In order to ensure that State Plans do not disproportionately impact these communities or increase the health and environmental burdens borne by these communities, the EPA strongly suggests that states consider the emissions of multiple pollutants beyond carbon dioxide (CO_2) when developing their Clean Power Plan compliance approach.

The Clean Power Plan provides states with significant flexibility to determine their own pathway to meet the 2030 carbon reduction targets. **By considering the many dimensions of power generation impacts together, the pathway to carbon mitigation can help achieve public health and equity benefits as well as climate benefits.** In this report, we build on this initial set of information provided by the EPA to model the regional health burden associated with emissions from each power plant covered by the Clean Power Plan in Ohio and analyze toxic releases and environmental hazards associated with these plants. We also assess socioeconomic and environmental hazard burdens for populations living near the plants, and develop a cumulative vulnerability index to reflect these burdens.

Findings and recommendations

1. Our models suggest that particulate matter ($PM_{2.5}$) attributable to Ohio power plant emissions is responsible for a high estimate of 2,130 premature deaths per year and tens of thousands of incidents of respiratory symptoms, asthma exacerbations and other health effects.[a] The majority of these particulate matter health impacts are attributed to coal plants.
   Reducing CO_2 emissions in Ohio under the Clean Power Plan has the potential to additionally reduce these harmful emissions and associated health impacts, particularly under a multi-pollutant approach that targets plants with high emission rates for multiple pollutants.

2. Populations living near many of Ohio's currently active power plants are disproportionately burdened by multiple socioeconomic, health and environmental stressors. For example, 88% of plants are located in communities with larger proportions of low income people; 76% are located in communities with a higher prevalence of disability; and 76% are located in communities with more elevated proportions of elderly people, compared to the Ohio median. These patterns are particularly strong near existing and proposed natural gas combined cycle plants.
   As such, while reductions should be prioritized at Ohio's dirtiest plants, an approach to the Clean Power Plan that relies on shifting generation from these dirtiest plants to existing and proposed natural gas combined cycle plants, rather than clean energy resources such as wind, solar, and energy efficiency, may increase associated hazards near already overburdened and vulnerable communities.

3. Ohio power plants are associated with numerous environmental health hazards in nearby communities in addition to their particulate matter air pollution impacts, including five coal ash impoundments with a high risk of failure resulting in leakage, and numerous groundwater measurements near four plants showing incidences showing illegal or advisory exceeded levels of radioactive particles and of heavy metals such as arsenic and manganese.
   Engagement with local communities can provide insight into these and other environmental public health concerns near power plants and in power plant-affected airsheds. The State Plan should seek to ameliorate these burdens by reducing Ohio's reliance on fossil fuels under the Clean Power Plan.

[a] The EPA COBRA modeled used reports both a "high" and "low" value and gives them equal weight.

Our analysis presents a baseline portrait of the impacts, hazards, and risks associated with the power plants in Ohio that are regulated under the Clean Power Plan. This report builds on the EPA's initial national analyses of co-benefits and environmental justice concerns by examining three significant facets of power generation in Ohio:

1. **Disease prevalence and demographic vulnerability near power generation:** We expand on the EPA proximity analysis by adding health vulnerability indicators (e.g., prevalence of disease or poor birth outcomes) and analyzing population characteristics (e.g. race, income level, age) for communities living near power plants (including coal, natural gas combined cycle (NGCC), fossil steam, planned, and recently retired).

2. **Environmental health hazard identification:** We analyze specific indicators of environmental health hazards near power plants, including the location and structural integrity of coal ash impoundments, toxic releases on and off the power plant site, groundwater well-monitoring data, and power plant compliance with applicable laws, including violations of federal environmental statutes.

3. **Particulate matter health impact modeling:** We analyze 2015 power plant criteria pollutant emissions and model the health impacts of associated primary and secondary particulate matter pollution, on a per-plant basis and aggregated for each county in the state.

This Executive Summary highlights the main findings from our analysis and discusses the implications of these findings for how Clean Power Plan implementation in Ohio may take into consideration public health and equity.

Vulnerable and overburdened populations

Our research finds that populations living near both coal and natural gas power plants in Ohio are in many cases burdened with a disproportionate share of environmental health hazards. These hazards include, for example, proximity to traffic and hazardous facilities. Communities living near power plants also have a larger share of socioeconomic and health vulnerabilities, such as elevated concentrations of people with low incomes, with less than a high school education, with disabilities, and over age 64 among their residents.

These vulnerabilities combine with other environmental stressors to create a cumulative burden on residents in these areas. This accumulation of burdens makes these residents more susceptible to impacts from exposures to environmental hazards attributable to power plants than populations without these burdens. Furthermore, while exposure to primary and secondary air pollutants from power generation affects populations over hundreds of miles, a growing body of scientific literature suggests that populations that live near all types of fossil-fueled generation facilities are at an elevated risk of experiencing adverse health outcomes [1, 2, 3, 4, 5].

Building on the EPA's proximity analysis, we analyze **demographic** (e.g. minority, low income), **environmental** (e.g. air quality, traffic proximity) and **health** indicators (e.g. health insurance rate, disability prevalence) for populations living within three miles of plants subject to the Clean Power Plan. We analyze our results for individual plants and for each power plant class (coal, natural gas combined cycle, etc.). We also include analysis of planned natural gas combined cycle plans as reported by the Ohio Power Plant Siting Board [6]. In recent years, ten of Ohio's coal plants that were considered in the development of the state's Clean Power Plan pollution reduction targets have retired. Six natural gas combined cycle plants are currently proposed and/or under construction–more than doubling the number that currently operate in the state.[1] Demographic measures of populations living within three miles of each power plant class, including percent low income, over age 64, and disabled, are shown in **Figure 1**.

[1] While these retirements are likely to bring much needed relief from many pollution-related hazards for surrounding communities and across the region, legacy pollution at these sites and potential re-powering of these plants with fossil fuels continue to present risks for these communities. These communities should therefore be consulted alongside other vulnerable and overburdened areas in development of Ohio's State Plan.

Our results indicate that populations that live within three miles of either coal or natural gas power plants regulated under the Clean Power Plan have a larger percentage of low income residents than either the state median or the state average. This trend is most pronounced for natural gas combined cycle plants, all five of which rank above the state median for nearby low income populations. The share of minority residents near natural gas combined cycle plants is also above the state median and higher than it is near coal plants. Areas near all classes of power plant have a larger proportion of residents without a high school education and of populations over the age of 64 than the state median. The elderly are particularly vulnerable to experiencing adverse health outcomes from environmental health stressors. Switching from coal to existing or planned natural gas plants therefore has the potential to increase generation and associated health and environmental burdens closer to vulnerable communities.

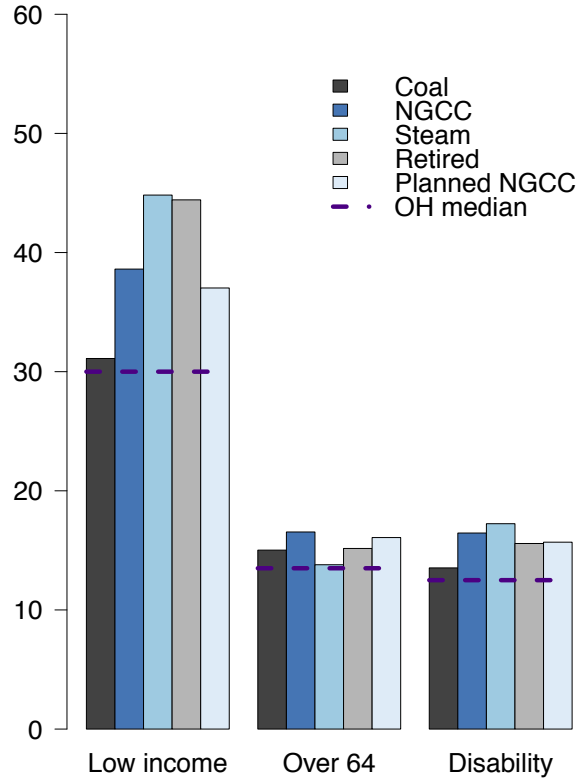

Figure 1: Demographics of populations that live within three miles of Clean Power Plan subject power plants, compared to populations living near planned NGCC plants and the state median.

We developed a Cumulative Vulnerability Index by aggregating our demographic, environmental and health results. This index averages percentile rankings for eighteen different vulnerability indicators (e.g. low income, access to health care, regional air quality) to reflect cumulative burden for populations living near affected power plants. The Cumulative Vulnerability Index, shown for the 15 highest ranking plants in **Figure 2** (including planned plants, and excluding retired plants), reveals that three of the five most vulnerable communities living near plants are living near existing or planned NGCC plants, suggesting that increased use of these plants may shift some burdens onto vulnerable populations. While not reflected in this figure, we also note that many of the recently retired plants were also located in vulnerable communities, presenting both concerns for legacy contamination in these areas as well as highlighting the importance of considering nearby communities in the case of future repowering to natural gas.

The Cumulative Vulnerability Index can be helpful to screen for vulnerable and overburdened populations for engagement under the Clean Power Plan to ensure that no increased burden is placed on these populations from this regulation and to develop approaches for

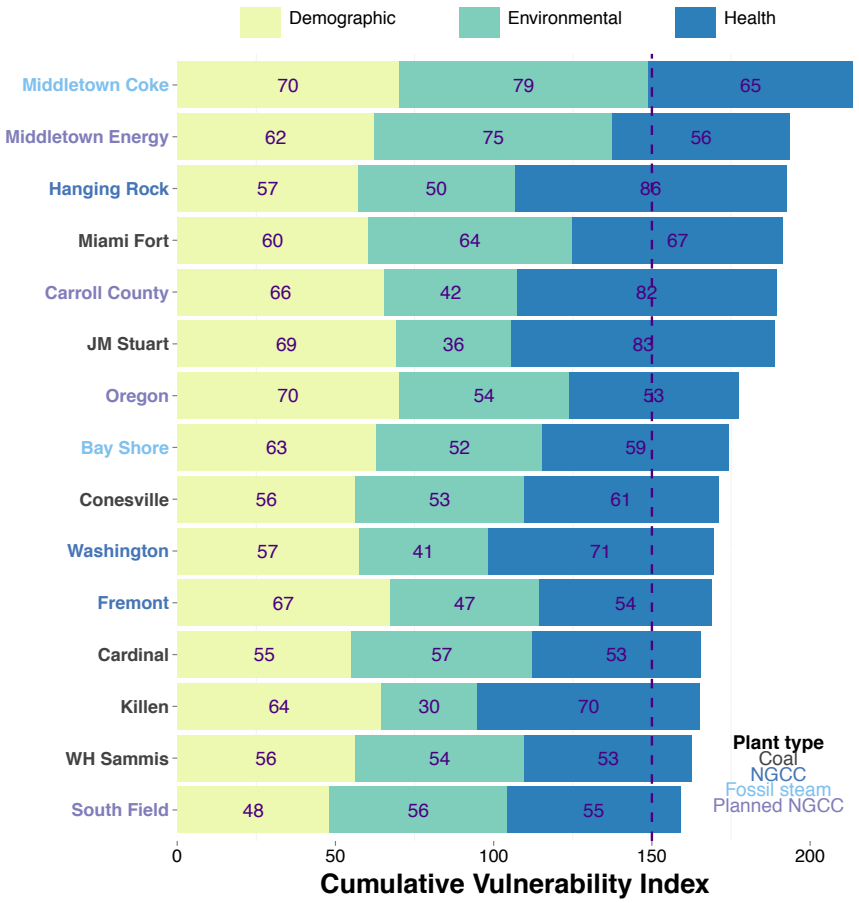

Figure 2: Cumulative Vulnerability Index reflecting aggregate demographic, environmental and health burdens for populations living within three miles of the 15 highest-ranked power plants, excluding retired and including proposed NGCC plants. A median score on all indicators gives an Index score of 150 (purple dashed line).

maximizing environmental benefits to these communities. The Index can also be used to inform approaches to decreasing environmental hazard and human health impacts on these populations.

Our results indicate that a State Plan that relies on increasing electricity generation at existing (or new) natural gas plants, rather than replacing coal generation with energy efficiency or renewable generation, may have the potential to increase the utilization of plants disproportionately located near low income and other vulnerable populations.

In addition to background vulnerability indicators reflected in the Cumulative Vulnerability Index, we also analyze environmental hazards associated with the plants themselves. Water well-monitoring data near coal ash impoundments show high levels of toxic releases of heavy metals; persistent bioaccumulative toxins and other health-harming contaminants that exceed allowable levels of radioactive alpha and beta particles; and arsenic and other contaminants at rates hundreds of times higher than the EPA's maximum contaminant level (MCL) standards, although all exceedances cannot necessarily be attributed to impound-

ments. While background levels prior to the coal ash impoundment's existence were not available for review, the fact that well water is a large source of drinking water for rural residents is cause for special concern with regards to exceedances above MCL and health advisory standards. Furthermore, nine different coal plants received up to eight million dollars in federal penalties for environmental violations in recent years, with 29 violations for coal plants in total, and NGCC plants received two violations. Coal plants in high minority and low income areas (ranking high on the EPA's "Demographic Index") areas received three times as many violations per plant as those in lower minority, higher income areas. Killen received the most violations, with 11, including seven for contaminant-related violations of the Clean Air Act or Clean Water Act.

These results, in aggregate, suggest that there is potential to reduce burdens on vulnerable communities through decreased reliance on fossil generation under the Clean Power Plan. However, if there is a switch from coal to existing natural gas-fired power plants or new power plants sited in vulnerable or historically overburdened areas, there is a risk of increasing near-source health burdens on socioeconomically and environmentally vulnerable communities or of shifting burdens among vulnerable communities. Given the wide distribution of levels of existing burden for communities living near all classes of power plants, extensive community input and careful modeling of projected changes in generation levels under any compliance plan should be encouraged to provide insight into whether demand, and associated health burdens, are likely to increase from these decisions.

Air pollutant emissions and public health

Our models suggest that particulate matter ($PM_{2.5}$) attributable to Ohio power plant emissions is responsible for thousands of premature deaths per year and tens of thousands of incidents of respiratory symptoms, asthma exacerbations and other health effects. Taking emissions and production of health-damaging criteria pollutants into consideration when developing carbon reduction strategies can help to reduce or eliminate some of these health burdens. Such multi-pollutant approaches to State Plans may target both the plants with the largest total health impacts, as well as those with the highest intensity of health impacts per megawatt-hour (MWh) of generation or per ton of CO_2.

We analyze emissions of CO_2, nitrogen oxides (NO_x) and sulfur dioxide (SO_2) from power plants in Ohio in 2015, and find a wide range among power plants of both total mass of emissions and in rate of emissions per MWh. NO_x and SO_2 contribute to elevated levels of secondary $PM_{2.5}$. NO_x also reacts in the atmosphere to form tropospheric ozone, a strong respiratory irritant which contributes to a wide range of cardiovascular and respiratory health impacts, particularly among members of already-vulnerable populations that suffer from vulnerability to and cumulative burdens of these exposures (e.g. low income, minority, the elderly, and those with pre-existing diseases). We use estimated primary $PM_{2.5}$ and these historic NO_x and SO_2 emissions to model health impacts from each plant using the EPA-developed Co-Benefits Risk Assessment (COBRA) model and an externally developed Air Pollution Emission Experiments and Policy (AP2) model. COBRA provides a low and a high estimate based on two different underlying epidemiological studies.

Case study: Avon Lake coal plant

- Particulate matter alone associated with 2015 emissions contributed to low and high estimates of **232 and 526 premature deaths** across the country.
- In 2015, emitted the **second highest total tonnage of SO_2** in the country.
- Located in Lorain County, which has the second-largest cumulative impact of Ohio power plant emissions, **highest per-capita impact**, and one of the highest asthma prevalence rates in the state.
- Highest cumulative impacts are on Lorain County and next-door Cuyahoga County, home to Cleveland; **air quality in both counties is designated non-attainment** for both ozone and particulate matter concentrations.
- Designated **in serious non-compliance** under the Clean Air Act for at least the last three years.

A number of power plants in Ohio have uniquely elevated rates or levels of total emissions of criteria air pollutants. The power plant Avon Lake, for example, has the second highest total emissions of SO_2 in the country, and emits SO_2 at a very high rate per MWh. A number of the highest-rate emitters in Ohio have been retired in recent years,[2] but plants like Avon Lake remain online and have widespread health impacts. Even though Avon Lake is located in a community that ranks low on many vulnerability indicators, the stack emissions from this plant affect air quality and health across the state and beyond.

Coal plants have higher rates of CO_2, NO_x and SO_2 than natural gas combined cycle plants, and are responsible for the largest total mass emissions for all of the criteria air pollutants examined in our analysis. **We find that particulate matter associated with pollution from power plant operations in Ohio in 2015 contributes to an estimated 940 (low estimate) or 2,130 (high estimate) premature deaths nationwide. The annual estimated costs of health burdens attributable to Clean Power Plan-affected power plants from our three models, including both mortality and non-fatal diseases, are $5.4 billion (AP2), $8.1 billion (COBRA low estimate), and $18.2 billion (COBRA high estimate).**

Approximately 90% of these $PM_{2.5}$ health impacts are attributable to the ten highest-impact plants. While a number of high-emitting power plants covered by the Clean Power Plan have come offline in recent years, the health impacts of the plants still online remain high. If we remove the power plants that were retired by the end of 2015 from our analysis, the estimated particulate matter health impacts from the COBRA model are $6.9 billion (low estimate), and $15.6 billion (high estimate), including 810 and 1,830 premature deaths in the low and high estimates, respectively.

The mortality estimates attributable to air pollutant emissions from power plant stacks for each county are mapped in **Figure 3**. Circle size represents the total nationwide mortality impacts from each plant. The blue lines outline federally designated non-attainment areas for National Ambient Air Quality Standards (NAAQS). Certain areas show both high aggregate health impacts as well as an existing burden of poor air quality on the county

[2] For example Ashtabula, retired in 2015, had the third highest rate of SO_2 emissions per MWh in the country.

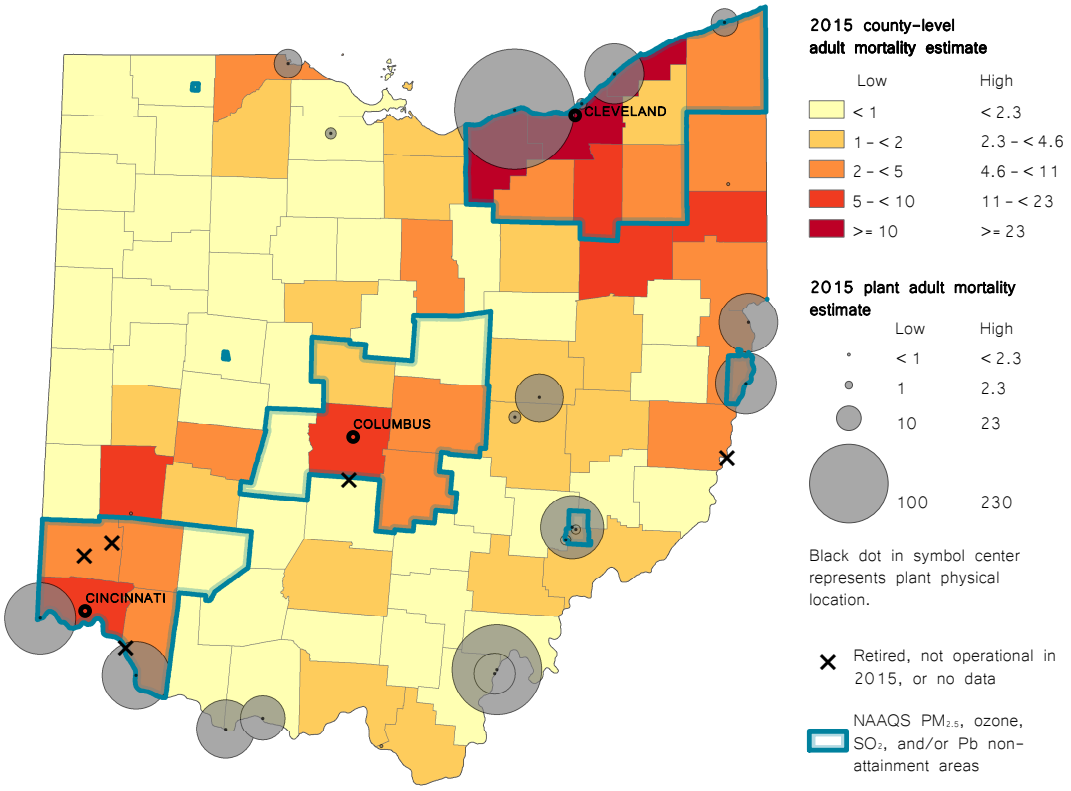

Figure 3: Modeled $PM_{2.5}$ mortality impacts by county from 2015 Ohio power plant emissions. Circle size represents each plant's nationwide mortality impact (80% of which are out of state). Blue outlines indicate non-attainment areas for ozone, $PM_{2.5}$, SO_2 or lead under National Ambient Air Quality Standards.

level. For example, Lorain County (home to Avon Lake) has the second highest cumulative health impacts, the highest per-capita health impacts, very high background rates of asthma, and is designated as non-attainment status for particulate matter and ozone under NAAQS standards.

It is important to note that 80% of the human health impacts from power generation occur outside of Ohio–and similarly, electricity generated outside the state releases air pollutant emissions that contribute to poor air quality and health impacts in Ohio. Finally, while the aggregate health impacts shown in **Figure 3** are heavily influenced by population density, we also analyze the per-capita health impacts and find that there are typically a disproportionate number of health impacts per capita in the counties that contain or are downwind from power plants that emit high levels of SO_2 and NO_x.

We compare emissions totals and rates to health impacts in **Figures 4a** and **4b**. In **Figure 4a** we compare total CO_2 emissions to the total estimated cost of $PM_{2.5}$ health impacts attributable to that plant. This plot highlights the plants that contribute to the highest total climate and public health burdens.

In **Figure 4b** we compare the rate of CO_2 emissions per MWh to the intensity of this health burden in cost per MWh. Emission rates of CO_2 from coal plants are relatively similar, but the health impacts vary greatly from plant to plant. **This plot therefore highlights where an individual measure to reduce electricity generation may**

have the greatest climate and public health co-benefits, as reducing a MWh of generation or ton of CO_2 may have greater health benefits at one plant than another. These health impacts only reflect particulate matter, but additional health benefits may result from lower levels of ozone, toxic releases, and other power plant impacts that were not modeled here.

Our health burden modeling only assesses the health impacts of primary and secondary $PM_{2.5}$ for each power plant compared to total CO_2 emissions, and does not include the health impacts of other harmful pollutants. An approach to regulation that evaluates the intensity of impacts per MWh can also be extended to reducing NO_x emissions, associated ozone formation, and toxic releases, thereby increasing potential health co-benefits.

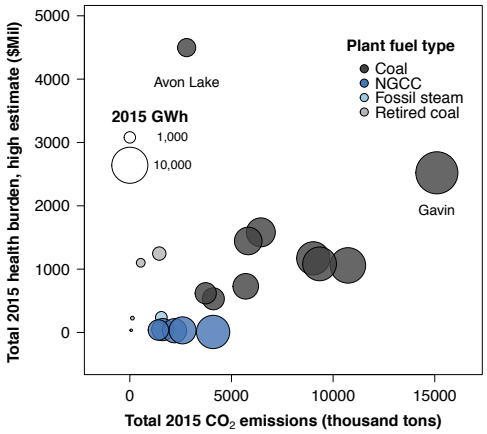

Figure 4a: 2015 cost of $PM_{2.5}$ health impacts from each power plant compared to total CO_2 emissions.

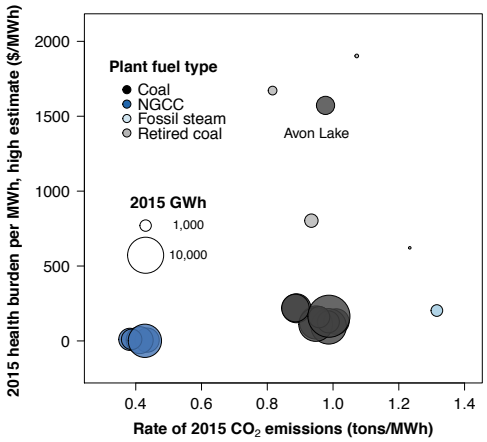

Figure 4b: Intensity of health impacts per MWh compared to intensity of CO2 emissions per MWh from each power plant in 2015.

Legacy from retired plants

The list of power plants covered by the Clean Power Plan includes ten power plants that were running in 2012, but which have since been retired. More may retire in coming years. Many of these retired plants have legacy environmental hazards, such as coal ash impoundments at four of these sites. Many are located near vulnerable communities. There is therefore a need for ongoing monitoring and careful assessment at any site that may be under consideration for retirement or repowering with natural gas.

For example, the Niles plant and Ashtabula plant, both retired, were in a continuous, most severe noncompliance status for the last 12 calendar quarters.[3] **Contamination exceedances were several thousand percent higher than the legal or advised limit for toxic releases for retired plants Muskingum and WC Beckjord, respectively.** Three retired plants, Muskingum, OH Hutchings, and WC Beckjord, all have one or more coal ash impoundments with the poorest structural integrity rating before failure (i.e. inability to contain coal ash), and have either high or significant hazard potential ratings. These hazard ratings mean that, should a failure of an impoundment occur, loss of life, property, and clean environment are highly probable.

[3]With the exception of Q4 2015 for Ashtabula which held a less egregious noncompliance status.

The communities living within three miles of these ten retired plants rank the highest for multiple socioeconomic, health and environmental hazard burdens, as shown in **Figure 1**. These results suggest that not only is ongoing monitoring important for these plants moving forward, but also that repowering of plants and monitoring of legacy environmental hazards may be important environmental health and equity considerations for these and potential future plant retirements. The socioeconomic status of existing nearby populations and the legacy environmental hazards identified in our analysis should also be taken into consideration when considering repowering these retired coal plants to natural gas combined cycle. Engagement with affected communities can help to identify environmental health concerns at these sites even after plant retirement.

Moving forward

Approaches to Clean Power Plan compliance that integrate health, environment and equity considerations hold potential to simultaneously mitigate climate change, improve public health, and alleviate disproportionate cumulative environmental burdens on vulnerable populations.

A multi-pollutant strategy that considers criteria and hazardous air pollutants and toxic releases along with CO_2 emission reductions holds the potential to reduce the numerous environmental health hazards and public health impacts associated with fossil fuel power generation in Ohio. Integration of climate, health, and equity factors will require careful consideration of the many dimensions of these issues. These issues include considerations of aggregate versus per-capita power plant impacts and hazards, and where, geographically, these impacts and hazards are disproportionately experienced.

Approaches to implementing the Clean Power Plan could result in shifting generation from coal to existing or planned natural gas combined cycle plants, or they could result in increasing energy efficiency and ramping up generation from renewables such as wind and solar. A combination of these outcomes may occur, depending on policy choices made by the state. In order to effectively limit the impacts of power plant pollution, Ohio's state plan should include these planned plants and any future fossil fuel-burning power plants under a single mass-based emissions standard by adopting the "New Source Complement" to the state's mass emissions target included in the Clean Power Plan.

Given the presence of vulnerable communities near existing and planned natural gas combined cycle generation, an emphasis on renewables and efficiency, rather than increased reliance on natural gas combined cycle generation, may be most likely to realize the many co-benefits of the Clean Power Plan without placing a disproportionate impact on vulnerable communities. Deployment of renewables and efficiency at faster rates than required to meet Clean Power Plan targets can help to achieve significant co-pollutant reductions at coal plants without increasing reliance on natural gas. Taken together, the data presented in this analysis provide a baseline of the environmental health and equity burdens associated with power generation in Ohio and can be used to prioritize and measure potential changes in these burdens when the state considers approaches to Clean Power Plan compliance and other energy regulations. Further engagement with disproportionately burdened communities identified in this analysis can highlight additional environmental and equity considerations and help to ensure that compliance plans ameliorate, rather than aggravate, the burdens of power generation on vulnerable communities.