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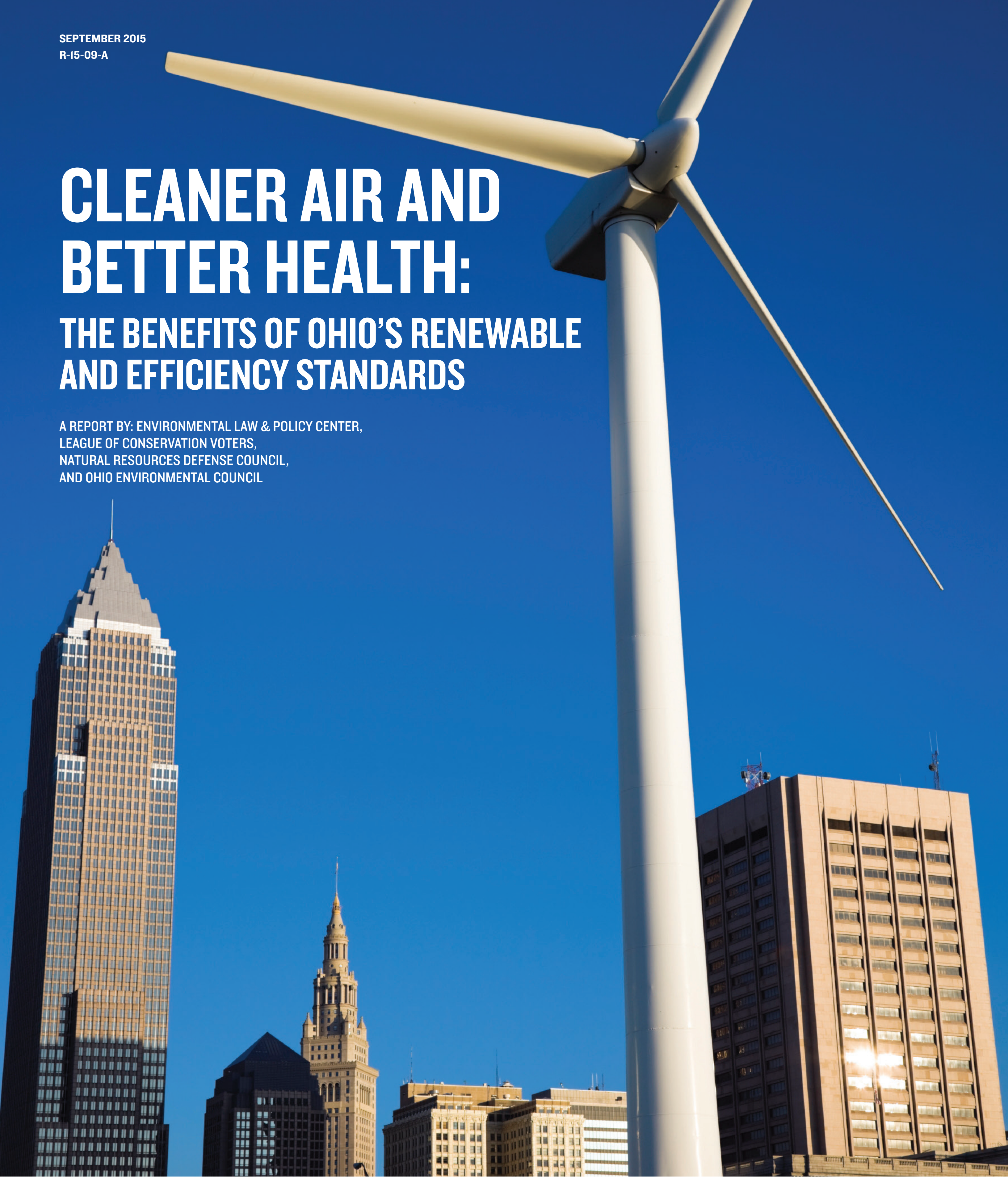
CLEANER AIR AND BETTER HEALTH:

THE BENEFITS OF OHIO'S RENEWABLE AND EFFICIENCY STANDARDS

A REPORT BY: ENVIRONMENTAL LAW & POLICY CENTER,
LEAGUE OF CONSERVATION VOTERS,
NATURAL RESOURCES DEFENSE COUNCIL,
AND OHIO ENVIRONMENTAL COUNCIL



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[UNLEASHING THE POWER OF GREEN]

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I. BACKGROUND

In 2014, Ohio Senate Bill 310 suspended Ohio's Energy Efficiency Resource Standard (EERS) and Renewable Portfolio Standard (RPS) (collectively referred to as the "clean energy standards") for two years and created an Energy Mandates Study Committee (EMSC) to examine the costs and benefits of these policies.[1] The legislation charged the EMSC with producing a report for the Ohio General Assembly and the governor by September 30, 2015. The committee is required to gather information and make recommendations to the legislature on eight specific criteria, including: *An assessment of the environmental impact of the renewable energy, energy efficiency, and peak demand reduction mandates on reductions of greenhouse gas and fossil fuel emissions.*[2]

The current report has been produced to inform the EMSC's evaluation of public health and environmental effects of using renewable energy and energy efficiency resources to displace electric generation from fossil fuels like coal and natural gas.

In short, resuming Ohio's energy efficiency and renewables standards by 2017 and maintaining them through the end of the next decade (2029) will displace generation from coal-fired power plants and reduce the particulate matter pollution they cause, thereby significantly reducing the public health effects associated with fossil fuel generation: ***averting thousands of premature deaths, hospital admissions, asthma-related emergency room visits, and heart attacks; avoiding tens of thousands of asthma attacks; and saving hundreds of thousands of lost work days***. Reinstating the energy efficiency and renewables standards will also generate environmental benefits by reducing carbon emissions from Ohio's electric power fleet, a greenhouse gas and significant contributor to climate change.

Reinstating Ohio's Energy Efficiency and Renewable Energy Standards Could in 2017 Help Avoid:

16,900	2,230	120	110	230	140
LOST WORK DAYS	ASTHMA ATTACKS	ASTHMA EMERGENCY DEPARTMENT VISITS	HOSPITAL ADMISSIONS	HEART ATTACKS	PREMATURE DEATHS

Between 2017-2029, the Reinstated Standards Could Help Avoid at Least:

335,770	44,930	2,420	2,060	4,470	2,820
LOST WORK DAYS	ASTHMA ATTACKS	ASTHMA EMERGENCY DEPARTMENT VISITS	HOSPITAL ADMISSIONS	HEART ATTACKS	PREMATURE DEATHS

Fossil fuel–fired power plants, and especially coal plants, emit pollutants that are harmful to human health, including particulate matter.[3] These emissions are related to increased frequency and severity of asthma attacks and other respiratory diseases and are known to contribute to heart attacks, cardiovascular diseases, and premature deaths.[4] Replacing fossil generation with cleaner energy sources can significantly reduce these negative health effects.

While this report does not specifically address toxic air emissions, coal plants also produce pollutants such as mercury, lead, polycyclic aromatic hydrocarbons, and acid gases, which can cause cancer, harm the developing nervous systems of children, and pose other human health hazards.[5] Using efficiency and renewable resources to displace electric generation from coal plants will yield significant co-benefits for the public—beyond those described in this report—by reducing these toxic air pollutants.[6]

Finally, fossil fuel combustion produces carbon pollution that contributes significantly to a warming global climate,[7] a trend that is already having adverse impacts in Ohio. For example, extreme rainfall events have become nearly 50 percent more frequent in Ohio over the past 60 years.[8,9] These heavy rains not only increase the risk of flooding, the second deadliest of all weather-related hazards in the nation, but can also lead to drinking water contamination.[10,11] Ohioans are experiencing this firsthand as increasingly intense rainfall events contribute to now-frequent toxic algae blooms in Lake Erie.[12,13] Transitioning away from fossil generation will be a key step in mitigating the worst environmental effects of climate change in the coming years.

These problems are of particular concern in Ohio. Prior to the establishment of the state's clean energy standards, Ohio relied almost exclusively on fossil fuels to generate electricity, with coal accounting for 85 percent of its electric power in 2008.[14] Despite some progress made over the past six years in transitioning to cleaner energy sources, coal-fired power plants still provided 67 percent and natural gas plants 18 percent of Ohio's electricity in 2014.[15] Ohio's power plants are among the largest emitters of carbon pollution of all state generation fleets in the nation.[16]

II. METHODS

The public health findings described in this report were generated by converting Ohio's EERS and RPS targets into quantitative environmental benefits and reduced public health effects using the Clean Power Plan Compliance Tool (M.J. Bradley and Associates) and the Powerplant Impact Evaluator (PIE) model, which incorporates the same peer-reviewed methodology used by the U.S. Environmental Protection Agency.[17,18]

The analyses were conducted in two parts. First, to measure the environmental effects of the EERs and RPS, the M.J. Bradley model was used to project the annual changes in fossil generation that would result if Ohio reinstated the EERS and RPS in 2017 and implemented these policies through 2029, relative to 2012 levels. To provide a conservative range of results across different assumptions, two scenarios were modeled. In one scenario, each incremental megawatt hour (MWh) of renewable energy and energy efficiency generation displaces 0.6 MWh of coal generation (i.e., 1:0.6 displacement), with the remaining 0.4 MWh displacing natural gas-fired generation.[19] The other scenario is even more conservative, with each MWh of renewable energy and energy efficiency displacing 0.4 MWh of coal (1:0.4). We then calculated the corresponding carbon pollution reductions that would result from full implementation of the clean energy standards under each of these two scenarios.

Second, the Clean Air Task Force (CATF) used the PIE model to convert the M.J. Bradley results into avoided health effects from the displacement of fossil generation with cleaner sources of electricity.

Further detail on the methodology is provided in Appendix A.

III. FINDINGS

This report quantifies the specific avoided public health effects that would result from reinstating Ohio's RPS and EERS through at least 2029.

In the seven years since their passage, Ohio's clean energy standards have reduced pollution and helped avert public health effects by replacing coal-fired generation and by decreasing overall electricity demand, which further reduces coal generation. The two-year freeze imposed by Senate Bill 310 stalled that progress. However, allowing the standards to resume in 2017 will put Ohio back on track to achieving substantial decreases in harmful pollution through a transition to clean energy.

We find that, along with other planned changes to Ohio's electricity mix, restoring the EERS and RPS by 2017 would:[20]

- In 2017 (with the freeze lifted), reduce particulate matter pollution enough to prevent at least 16,900 lost work days, 2,230 asthma attacks, 120 asthma emergency department visits, 100 hospital admissions, 230 heart attacks, and at least 140 premature deaths;

- prevent at least 326,600 lost work days, 43,190 asthma attacks, 2,350 asthma emergency department visits, 2,010 hospital admissions, 4,340 heart attacks, and at least 2,730 premature deaths in total between 2017 and 2029; and

- reduce Ohio's annual carbon pollution by about 10 million tons between 2017 and 2029—equivalent to avoiding emissions from the electricity consumed over the course of a year at 1 million homes.[21]

By allowing Ohio's clean energy standards to resume in full by 2017, the Ohio legislature will protect thousands of people—particularly vulnerable populations such as children and the elderly—from premature deaths, heart attacks, emergency room visits, asthma attacks, and lost work days.[22]

It is also notable that the environmental benefits of reduced carbon pollution would help Ohio satisfy the Clean Power Plan, which was finalized by the U.S. Environmental Protection Agency on August 3, 2015.[23] These limits give states flexibility and discretion to design a customized plan that capitalizes on each state's own energy mix and policy goals. With this flexibility, Ohio has the option to incorporate renewable energy and energy efficiency into its strategy to reduce carbon emissions. Recent analysis indicates that by lifting the freeze on Ohio's clean energy standards, along with other planned changes to its power sector, the state would dramatically reduce its carbon emissions to would meet its Clean Power Plan carbon pollution limit.[24] Moreover, prior analysis of the proposed Clean Power Plan rules indicates that relying on the EERS and RPS can help Ohio cost-effectively reduce carbon emissions while lowering electricity bills for Ohioans.[25]

Below are detailed findings of the health effects projected to occur when fossil generation in Ohio is displaced, under two scenarios. As described above, scenario 1 conservatively assumes that each MWh of renewable energy and energy efficiency generation displaces 0.6 MWh of coal. Scenario 2 is even more conservative and assumes that each MWh of renewable energy and energy efficiency displaces 0.4 MWh of coal. It is important to note that neither situation eliminates coal from Ohio's resource mix. Rather, each scenario reduces coal generation proportionately as more renewable energy and energy efficiency enter the system.

As shown in Tables 1 and 2, resuming the EERS and RPS in full by 2017 would yield significant benefits by avoiding the harmful public health effects of fossil fuel generation, with these benefits increasing each year as the state's clean energy standards ramp up. This is true under both scenarios considered.

As noted in tables 1 and 2, Ohio's clean energy standards can also substantially reduce the carbon pollution associated with the state's power sector. Carbon emissions reductions from Ohio's fossil fuel–fired power plants will generate environmental benefits by reducing a key greenhouse gas that contributes to climate change.26 Further information is provided in the Appendix demonstrating the significant downward trajectory of carbon emissions between 2017 and 2029 under both coal displacement scenarios analyzed.

Table 1: Avoided Health Impacts—Scenario 1 (1 MWh:0.6 MWh Coal Displacement)						
	Mortality	Hospital Admissions	Asthma ER Visits	Heart Attacks	Asthma Attacks	Lost Work Days
2017	140–370	100	120	230	2,230	16,900
2018	160–410	120	140	250	2,510	19,040
2019	180–460	130	150	280	2,800	21,170
2020	200–520	150	170	320	3,190	24,120
2021	210–530	150	180	330	3,270	24,760
2022	210–550	160	180	340	3,360	25,390
2023	220–560	160	190	350	3,440	26,030
2024	220–570	160	190	350	3,530	26,660
2025	230–590	160	200	360	3,610	27,300
2026	250–630	180	210	390	3,870	29,290
2027	250–650	190	220	400	3,990	30,170
2028	270–690	190	230	430	4,240	32,070
2029	280–710	210	240	440	4,350	32,870
Total	2,820–7,240	2,060	2,420	4,470	44,390	335,770

Table 2: Avoided Health Impacts—Scenario 2 (1 MWh:0.4 MWh Coal Displacement)						
	Mortality	Hospital Admissions	Asthma ER Visits	Heart Attacks	Asthma Attacks	Lost Work Days
2017	140–370	100	120	230	2,230	16,900
2018	160–410	120	140	250	2,510	19,040
2019	180–460	130	150	280	2,800	21,170
2020	200–520	150	170	320	3,190	24,120
2021	210–530	150	180	330	3,270	24,760
2022	210–550	160	180	340	3,360	25,390
2023	220–560	160	190	350	3,440	26,030
2024	220–570	160	190	350	3,530	26,660
2025	230–590	160	200	360	3,610	27,300
2026	230–600	180	200	370	3,700	27,930
2027	240–610	180	210	380	3,770	28,490
2028	240–630	180	210	390	3,850	29,130
2029	250–640	180	210	390	3,930	29,680
Total	2,730–7,040	2,010	2,350	4,340	43,190	326,600

IV. CONCLUSION

Ohio is currently reviewing its clean energy policies and will be making recommendations that determine the future of Ohio's energy landscape. These recommendations will presumably be based, at least in part, on the projected environmental and public health effects of deploying greater levels of energy efficiency and renewable energy.

Our analyses strongly suggest that reinstating Ohio's EERS and RPS by at least 2017 and implementing these policies in full through the next decade and a half would help the state shift to clean energy sources, reduce emissions of harmful pollutants, and decrease greenhouse gas emissions. As these findings demonstrate, Ohio's clean energy policies hold significant untapped potential to protect the environment and safeguard public health, particularly the health of children, pregnant women, the elderly, and other vulnerable populations, as well as those who work and play outdoors.

From the environmental and public health perspective, these policies are performing just as intended when they were first enacted in 2008. Delaying their reinstatement would only withhold these critical benefits from the people of Ohio.

ENDNOTES

1 The standards were established by Ohio Senate Bill 221 (Schuler by Request, 127-GA), archives.legislature.state.oh.us/bills.cfm?ID=127_SB_221.

2 Temp Law , Section 4 (C) (7), page 35, archives.legislature.state.oh.us/BillText130/130_SB_310_EN_N.pdf

3 *See* Union of Concerned Scientists, "Environmental Impacts of Coal Power: Air Pollution," http://www.ucsusa.org/clean_energy/coalvswind/c02c.html#.VeXqD_2FOzl; *see also* American Lung Association, State of the Air 2015, "Particle Pollution: Where Does Particle Pollution Come From?" http://www.stateoftheair.org/2015/health-risks/health-risks-particle.html#wheredoes; U.S. Environmental Protection Agency (hereinafter EPA), "Clean Energy: Air Emissions," www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html.

4 *See* EPA, "Six Common Air Pollutants," www.epa.gov/airquality/urbanair. *See also* EPA, "Particle Pollution: Health," http://www.epa.gov/airquality/particlepollution/health.html; American Lung Association, State of the Air 2015, "Particle Pollution: What Can Particles Do To Your Health?" http://www.stateoftheair.org/2015/health-risks/health-risks-particle.html#cando.

5 *See* EPA, "Clean Energy: Air Emissions." *See also*. EPA, information on the health impacts of mercury is available at www.epa.gov/mercury/effects.htm; arsenic at www.epa.gov/ttnatw01/hlthef/arsenic.html; lead at www.epa.gov/airquality/lead; acid gases at www.epa.gov/acidrain; and polycyclic aromatic hydrocarbons at www.epa.gov/osw/hazard/wastemin/minimize/factshts/pahs.pdf.

6 Schwartz, J., et al., *Health Co-Benefits of Carbon Standards for Existing Power Plants*, Harvard University, Boston University, and Syracuse University, September 30, 2014, www.chgeharvard.org/sites/default/files/userfiles2/Health%20Co-Benefits%20of%20Carbon%20Standards.pdf.

7 EPA, "Clean Energy: Air Emissions," www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html.

8 Extreme rainfall is classified by identifying the 64 largest 1-day precipitation totals during the 64-year period of analysis. Madsen, T., and N. Willcox. *When It Rains It Pours: Global Warming and the Increase in Extreme Precipitation from 1948 to 2011.* Environment America Research & Policy Center, 2012.

9 Downer, C., et al., *2014 National Climate Assessment: Midwest*, U.S. Global Change Research Program, nca2014.globalchange.gov/report/regions/midwest#intro-section-2.

10 Curriero, F.C., et al. "The Association Between Extreme Precipitation and Waterborne Disease Outbreaks in the United States, 1948–1994." *American Journal of Public Health* 91 (2001): 1194-1199.

11 Ashley, S.T., and W.S. Ashley. "Flood Fatalities in the United States." *Journal of Applied Meteorology and Climatology* 47 (2008): 805-818, journals.ametsoc.org/doi/pdf/10.1175/2007JAMC1611.1.

12 Ohio State University, "Climate Change Brings Mostly Bad News for Ohio: Big Algae Bloom in Lake Erie, Very Dry 2015 Forecast," Science Daily, May 20, 2014, www.sciencedaily.com/releases/2014/05/140520120135.htm; National Oceanic and Atmospheric Administration, "NOAA, partners predict severe harmful algal bloom for Lake Erie: Heavy June rains causing heavy nutrient runoff into lake basin," July 9, 2015, www.noaanews.noaa.gov/stories2015/20150709-noaa-partners-predict-severe-harmful-algal-bloom-for-lake-erie.html.

13 Troy, Tom, "Mayor Collins Speaks on Toledo Water Crisis at Great Lakes Gathering," *Toledo Blade*, September 24, 2014, www.toledoblade.com/local/2014/09/24/Mayor-Collins-speaks-on-Toledo-water-crisis-at-Great-Lakes-gathering.html; Henry, Tom, "Lake Erie algal bloom could grow difficult," Toledo Blade, August 26, 2015, www.toledoblade.com/local/2015/08/26/Lake-Erie-algal-bloom-could-grow-difficult.html#QSuTOoPzq0GR5bJh.99.

14 Energy Information Administration, "Electricity: Ohio Electricity Profile," Table 5: Electric Power Industry Generation by Primary Energy Source," July 8, 2015, www.eia.gov/electricity/state/Ohio.

15 Energy Information Administration, "Ohio: State Profile and Energy Estimates," last updated March 19, 2015, www.eia.gov/state/?sid=OH.

16 Van Atten, C., A. Saha, and L. Reynolds, *Benchmarking Air Emissions*, M.J. Bradley & Associates, May 2013, www.mjbradley.com/sites/default/files/Benchmarking-Air-Emissions-2013.pdf. *See also* Van Atten, C., et al., *Benchmarking Air Emissions*, M.J. Bradley & Associates, July 2015, www.nrdc.org/air/pollution/benchmarking/files/benchmarking-2015.pdf.

17 *See* "Clean Power Plan Evaluation Tools," mjbradley.com/about-us/case-studies/clean-power-plan-evaluation-tools.

18 *See* Abt Associates Inc., *Technical Support Document for the Powerplant Impact Evaluator Software Tool*, July 2010, www.catf.us/resources/publications/view/137.

19 1 MWh is equivalent to 1,000 kilowatts of electricity used continuously for one hour.

20 All reduction s are relative to 2012 levels. Health impact estimates from the PIE include Ohio as well as downwind areas outside of the state. A large portion of the impacts would be felt in-state, however, given the significant proportion of emissions sourced from fossil generation in Ohio as well as the large population centers likely to be affected by pollution emissions.

21 In 2012, 113.93 million homes in the United States consumed 1,375 billion kilowatt-hours of electricity. On average, each home consumed 12,069 kWh of delivered electricity, with about 1,328.0 lbs CO_2 per megawatt-hour for delivered electricity, assuming transmission and distribution losses at 7.2%. See EPA, Greenhouse Gas Equivalencies Calculator, www.epa.gov/cleanenergy/energy-resources/calculator.html.

22 M.J. Bradley's projections account for the two-year delay in implementation of the standards under SB 310. The model assumes that the EERS and RPS are frozen at current levels through the end of 2016, at which point they resume their trajectory. Note that for the purposes of this analysis, 2012 is the baseline to which we compare all other years. A more detailed projection of what might replace the lost output from Ohio's retiring coal plants if the EERS and RPS were reinstated would require a dispatch model that factors in cost information. This is because even in the absence of SB 310 some renewable energy and energy efficiency, albeit in smaller amounts, will still enter the resource mix based on market forces. Projections of this sort are not within the scope of the M.J. Bradley tool.

23 *See* EPA, "Clean Power Plan for Existing Power Plants," August 2015, www2.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants. *See also* EPA, "Clean Power Plan: State at a Glance (Ohio)," August 2015, www.epa.gov/airquality/cpptoolbox/ohio.pdf.

24 Natural Resources Defense Council, "Issue Brief: Ohio's Pathway to Cutting Carbon Polltion," August 2015, www.nrdc.org/air/clean-power-plan/files/CPP-Ohio-Compliance-IB.pdf.

25 *See, e.g.*, PJM Interconnection, *PJM Economic Analysis of EPA's Proposed Clean Power Plan: State-Level Detail*, March 2, 2015, www.pjm.com/~/media/documents/reports/20150302-state-level-detail-pjm-economic-analysis-of-epas-proposed-clean-power-plan.ashx. *See also* Natural Resources Defense Council, "Ohio and the Clean Power Plan: Affordable, Reliable, Achievable," June 2015, www.nrdc.org/energy/files/oh-clean-power-plan-IB.pdf; Public Citizen, "Ohio: Clean Power, Clear Savings," June 16, 2015, www.citizen.org/SSLPage.aspx?pid=6568. While the cited reports analyze Ohio's potential for cost savings when using clean energy to meet the draft Clean Power Plan, similar analyses of the final rules are pending and will be available in the fall of 2015.

26 *See* EPA, "Clean Energy: Air Emissions."

Appendix A:
ANALYTICAL METHODS

The findings described in this report were generated by converting Ohio's EERS and RPS targets into quantitative environmental and public health benefits, based on an M.J. Bradley & Associates (M.J. Bradley) model and analyses conducted by the Clean Air Task Force (CATF) and MSB Energy Associates.

The M.J. Bradley model was used to conduct the initial environmental effects, determining the fossil generation reductions that would result from Ohio's EERS and RPS and the corresponding carbon pollution reductions. CATF and MSB Energy then used these estimates of pollution reductions to calculate the avoided health effects of implementing Ohio's clean energy standards.

Details of the two-step analysis are provided below.

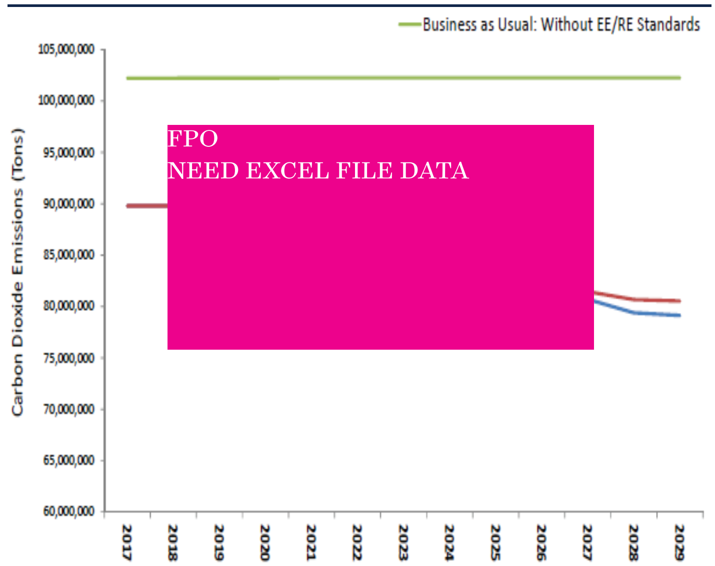
M.J. Bradley's Clean Power Plan Compliance Tool was used to estimate the avoided carbon emissions associated with implementing the RPS and EERS from 2017 to 2029.[1] This tool is designed to perform a simple resource analysis for each state, simulating the overall changes in generation that result from specified policies—in this case, displacement of coal- and natural gas–fired generation with full utilization of the RPS and EERS—under a given set of background assumptions.

For this report, we projected carbon emissions reductions in Ohio from 2017 to 2029, relative to 2012, using the Compliance Tool with the following assumptions:

- Ohio achieves annual incremental energy efficiency savings of 1% between 2017 and 2020. Annual incremental savings increase to 2% in 2021 and remain at that level through the end of the Clean Power Plan Compliance period. This is consistent with the amended requirements of Senate Bill 310.
- Generation from renewable energy sources is fixed at 2.5% of electricity sales through 2016. Starting in 2017, this share is increased by 1 percentage point annually until it reaches 12.5% of sales in 2026. The share of renewable energy in Ohio's generation mix remains unchanged thereafter. This is consistent with the amended requirements of Senate Bill 310.
- About one-third of Ohio's existing coal fired capacity (7 GW) is projected to be retired by 2020 (based on a list of announced coal plant retirements compiled by M.J. Bradley). Full implementation of the EERS and RPS ensures that this generation is not replaced by a ramp-up of other coal-fired power plants. Instead, this generation is replaced with a mix of energy efficiency, renewable energy, and natural gas–fired generation. In a given year and scenario, if the amount of incremental energy efficiency and renewable energy exceeds the resource gap left by retiring coal units, then the EE and RE resources further decrease overall coal-fired generation. For purposes of this analysis, we considered two scenarios: one in which incremental energy efficiency and renewable energy would displace fossil generation in a 60:40 ratio, with 60 percent displacing coal-fired generation and 40 percent displacing natural gas resources; and one in which these clean energy sources would displace fossil fuels based on a 40:60 ratio, with 40 percent displacing coal-fired generation and 60 percent displacing natural gas resources.
- Contributions of other generating resources including nuclear and hydro remain constant at their 2012 levels.
- Based on average emissions factors, coal plants produce 2,126 pounds of carbon dioxide per MWh and natural gas plants produce 963 pounds of carbon dioxide per MWh.

Figure 1 shows the significant downward trajectory of carbon emissions between 2017 and 2029 under both coal displacement scenarios analyzed.

FIGURE 1: OHIO CARBON POLLUTION EMISSIONS



CATF conducted the second part of the analysis, projecting the resulting public health effects from full implementation of the EERS and RPS from 2017 to 2029. Since coal-fired power generation is the primary source of such impacts, CATF used the M.J. Bradley model's avoided coal generation projections as the basis for calculating avoided health effects. Health impact estimates from the PIE include Ohio as well as downwind areas outside of the state. A large portion of the impacts would be felt in-state, however, given the significant proportion of emissions sourced from fossil generation in Ohio as well as the large population centers likely to be affected by pollution emissions.

CATF made a few key assumptions in conducting the health impacts analysis. For in-state generation, CATF used the M.J. Bradley model's projections regarding percentage of coal generation in each year. With respect to power imports to Ohio from out of state, the M.J. Bradley data provided overall import estimates, without specifying a percentage of imported coal generation. In estimating imports into Ohio, the M.J. Bradley model adjusted electricity demand beyond 2012 levels to reflect any incremental energy efficiency savings. CATF reviewed the Electric Power Annual and determined that coal plants made up 80.7 percent of the fossil generation in surrounding states that would be likely to be imported to Ohio (i.e., that would not be necessary to serve baseload in those states).[2] CATF used that fraction to convert the M.J. Bradley calculation of reductions in overall imports to reductions in imports from coal generation.

CATF then used the Powerplant Impact Evaluator (PIE) model to calculate the health effects per MWh of coal generation. The PIE model was developed by Abt Associates, the consulting firm used by the U.S. Environmental Protection Agency (EPA) to assess the avoided health effects of federal air pollution regulations. The PIE model incorporates the same peer-reviewed methodology used by EPA, which is widely accepted in the scientific community.

The PIE model uses data on the emissions from each coal-fired power plant in the geographic area under consideration, based on each plant's reports to the EPA's Continuous Emissions Monitoring Site (CEMS) database. This emissions data is combined with weather data and atmospheric chemistry to determine each plant's contribution to the concentration of air pollutants in the atmosphere. The model uses these concentrations as inputs into a set of equations that relate pollutant levels to specific adverse health effects. These equations are derived from the peer-reviewed health studies of dose-response relationships used by EPA in assessing the benefits of its air pollution regulations. Running the PIE model thus produces estimates of each coal plant's annual health impacts in each county affected by the plant's emissions. Combining these county-level results provides health impacts on a statewide level. A more detailed description of the PIE model is given in the last section of this Appendix.

To estimate the health impacts of future reductions in coal-fired power generation, CATF used the above analysis and calculated the health impacts per MWh of generation for both in-state and out-of-state generation. First, CATF determined the health impacts caused by Ohio coal plants in 2012 and ran the model using 2012 emissions data. Second, CATF divided the health impacts of Ohio's coal-fired generation by the amount of MWh generated in Ohio from coal in 2012 to produce estimates of per-MWh health impacts caused by coal plants in the state.

CATF's analysis also accounts for the fact that roughly one-quarter of the power used in Ohio comes from out of state. It is quite difficult to model the exact sources of imported electricity. To address this, CATF assumed that the power coming into Ohio would, for the most part, come from those states that border Ohio: Indiana, Michigan, Pennsylvania, Kentucky, and West Virginia. CATF treated those five states as a single block and calculated the health impacts per unit of coal generation from the entire block, using the same approach described for Ohio plants above.

Finally, CATF multiplied the estimated impacts per MWh of coal generation for Ohio and the surrounding states by the MWh changes in coal generation and coal-generated imports by year resulting from the EERS and RPS. This calculation produced the annual health effect figures set forth in Tables 1 and 2 of the report.

DESCRIPTION OF POWERPLANT IMPACT EVALUATOR MODEL METHODOLOGY

PIE was developed specifically to estimate the health and economic impacts of electric generating units (EGUs) in the United States, focusing on the impacts of particulate matter less than 2.5 microns in aerodynamic diameter (PM2.5). This air pollutant has been linked to a variety of serious health effects, including asthma attacks, chronic bronchitis, hospital admissions, and premature mortality.

To estimate the PM2.5-related benefits associated with reducing emissions from EGUs, the PIE model first calculates the impact on ambient air quality. Then, using the results from epidemiological studies, it estimates the number of adverse health impacts (e.g., avoided deaths), and finally, it estimates the associated economic benefits (the latter are not included in this report). This three-step process is the standard approach for evaluating the health and economic benefits of reduced air pollution. EPA used this approach when evaluating the National Ambient Air Quality Standards (U.S. EPA, 2006), the Clean Air Act (U.S. EPA, 1999b), the benefits of reducing greenhouse gases (Abt Associates Inc., 1999), the health effects of motor vehicles (U.S. EPA, 2000; 2004), and other major regulations.

Abt Associates developed the PIE tool to support assessments of the human health benefits of air pollution reductions and their associated economic benefits. PIE is the result of years of research and development and reflects methods that are based on the peer-reviewed health and benefits analysis literature.

PIE is based on a damage function approach, which involves modeling changes in ambient air pollution levels, calculating the associated change in adverse health effects, such as premature mortality, and then assigning an economic value to these effects. For changes in the concentrations of particulate matter, this is typically done by translating a change in pollutant levels into associated changes in human health effects. PIE has the capability to translate these health effects into economic values.

The process involves health impact functions, which are derived from concentration-response functions reported in the peer-reviewed epidemiological literature. A typical health impact function has four components:

1. an effect estimate, which quantifies the change in health effects per unit of change in a pollutant and is derived from a particular concentration-response function from an epidemiology study;
2. a baseline incidence rate for the health effect;
3. the affected population; and
4. the estimated change in the concentration of the pollutant.

The result of these functions is an estimated change in the incidence of a particular health effect for a given change in air pollution. Examples of health effects that have been associated with changes in air pollution levels include premature mortality, hospital admissions for respiratory and cardiovascular illnesses, and asthma exacerbation. Finally, the calculation of total avoided health effects involves summing estimated benefits across all non-overlapping health effects, such as hospital admissions for pneumonia, chronic lung disease, and cardiovascular-related problems.

A PIE analysis relies on first estimating a reduction in air pollution emissions. The determination of the emission reduction occurs outside of PIE and is used as input to the PIE analysis. In the case of the present study, the emission factors were provided to CATF by M.J. Bradley & Associates. After the user enters this information into PIE, the model then estimates:

1. the reduction in ambient PM2.5 levels in each county in the continental United States; and
2. the associated reduction in the incidence of various adverse health effects.

For detailed information on each step, see technical support documents for the PIE.[3]

ENDNOTES

1 *See* mjbradley.com/about-us/case-studies/clean-power-plan-evaluation-tools.

2 *See* Energy Information Administration, *Electric Power Annual* (most recent data is 2013), www.eia.gov/electricity/annual/.

3 *See* Abt Associates Inc., *Technical Support Document for the Powerplant Impact Evaluator Software Tool*, July 2010, www.catf.us/resources/publications/view/137.