Illinois Health Impacts from Transitioning to 100% Carbon-Free Electricity

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Dr. Paul Meier and Professor Tracey Holloway
The Holloway Group @ SAGE
Nelson Institute for Environmental Studies, University of Wisconsin-Madison

Summary

This study considers the potential air quality and health impacts from decarbonizing Illinois' electricity sector by 2030, consistent with the Clean Energy Jobs Act (CEJA).[1] The proposed efforts to reduce power plant greenhouse gas emissions will simultaneously reduce health-damaging air emissions, including nitrogen oxides (NO_x), sulfur dioxide (SO_2), and fine particulate matter ($PM_{2.5}$). By reducing these emissions, efforts to decarbonize the electricity sector benefit clean air and public health. Scientists at the University of Wisconsin--Madison used the U.S. EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to estimate the health benefits of avoided $PM_{2.5}$ exposure resulting from this clean energy policy change.[2] Total $PM_{2.5}$ includes direct emissions, as well as nitrate and sulfate particles formed in the atmosphere due to emissions of NO_x and SO_2. Illinois residents were projected to avoid annually: 3,570 lost-work days, 1,980 cases of respiratory and asthma symptoms, 3 - 28 heart attacks, and 30 - 69 premature deaths. These health benefits, especially the avoided deaths, are valued at $293 and $740 million dollars per year, as summarized in Table 1. These estimates reflect only $PM_{2.5}$ health impacts; additional health benefits would be expected due to avoided exposure to SO_2 and NO_2, as well as avoided exposure to near-surface ozone associated with NO_2 emissions. This work was supported by funding from the Joyce Foundation, with research design developed in collaboration with the Respiratory Health Association.

Table 1. Annual Health Benefits by 2030
Illinois Clean Energy Jobs Act Electricity Sector Provisions

Health Benefits ($million)	Avoided Lost Workdays	Avoided Respiratory Symptoms	Avoided Non-Fatal Heart Attacks	Avoided Premature Deaths
$293-740	3,570	1,980	3-28	30-69

This research was supported by grants from the Joyce Foundation and McKnight Foundation.

Background

The provisions in the Clean Energy Jobs Act (CEJA) would commit Illinois to 100% renewable energy by 2050, with state-based electricity generating resources completely derived from carbon-free resources by 2030. While the legislation is principally aimed at addressing climate change with consideration of statewide economic development, reductions in power plant pollutants would also improve air quality and public health.

This assessment considers emissions reductions for the electricity sector, for which coal and natural gas power plants supplied 17% and 13%, respectively, of Illinois' generation mix in 2020.[3] These same power plants were responsible for 19,100 tons of nitrogen oxides (NO_x) and 36,100 tons of sulfur dioxide (SO_2) in 2020.[4] In the atmosphere NO_x and SO_2 react to form fine particulate ($PM_{2.5}$), an air pollutant that exacerbates pulmonary and respiratory health conditions and can cause premature death.[5,6] Fine particulates may also be directly emitted from fossil fuel burning. Replacing fossil fuel power plants, especially coal, with renewable energy leads to improved air quality and health outcomes due to a reduction of these co-pollutants.[7]

This study focuses only on $PM_{2.5}$ health impacts, due to the study methodology discussed below. Reduced emissions of SO_2 and NO_2 would yield additional health benefits because direct exposures to SO_2 and NO_2 pose direct health risks. In addition, reduce NO_2 emissions from the power sector would be expected to reduce near-surface ozone, leading to additional health benefits.

With funding provided by the Joyce Foundation and McKnight Foundation, scientists at the University of Wisconsin–Madison conducted this study in collaboration with the Respiratory Health Association.

Results

The COBRA model is a reduced-form screening tool developed by the U.S. EPA to estimate potential air quality and health benefits from emission changes. COBRA calculates annual average $PM_{2.5}$, including directly emitted and chemically formed particles. A range of health impacts associated with $PM_{2.5}$ exposure are calculated, based on risk factors included in COBRA and drawn from prior epidemiological research. These health outcomes are monetized in a manner consistent with EPA benefit-cost analysis. Here, COBRA was used to model the potential benefits of decarbonizing Illinois' electricity sector.

The county-level improvement in ambient $PM_{2.5}$ concentration is illustrated in Figure 1. All of Illinois realized some reduction with the greatest improvement corresponding to counties with coal and natural gas power plant facilities. As a requirement of CEJA, electricity generation would be emission-free by 2030. To avoid over-estimating benefits attributable to CEJA, this analysis excluded emissions reductions for facilities with pending or announced retirements.

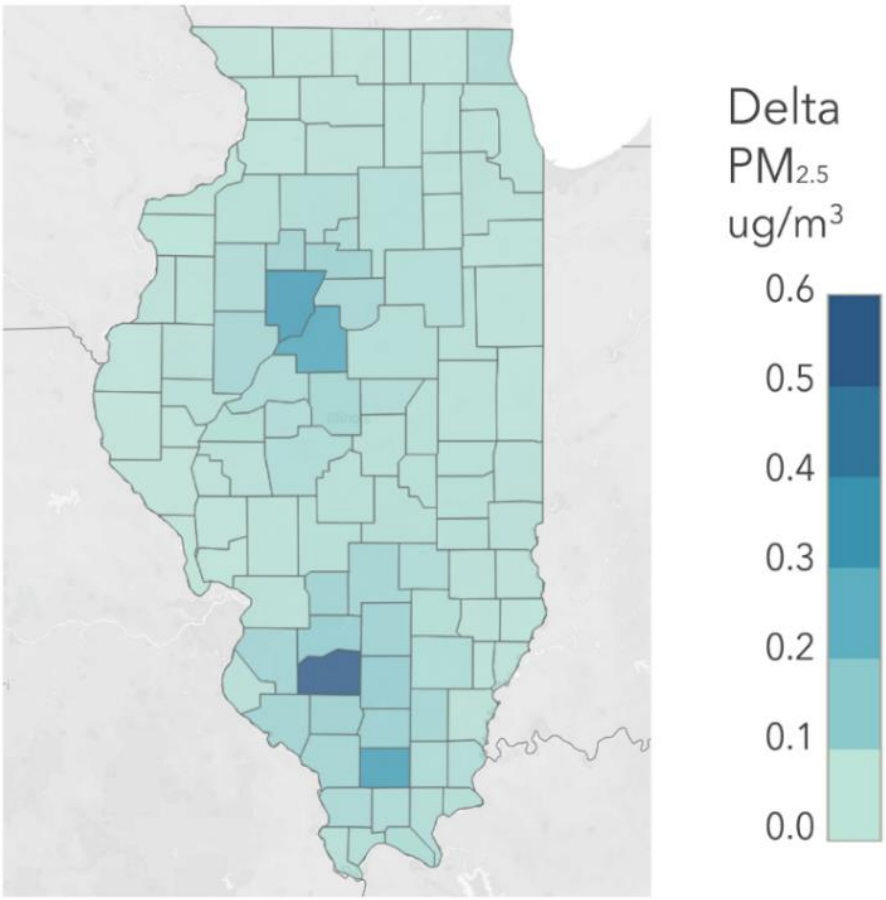

Figure 1. COBRA-estimated improvement in ambient $PM_{2.5}$ concentration associated with the proposed CEJA.

Figure 2 illustrates the COBRA-estimated avoided health impacts. The proposed100% carbon-free electricity is projected to avoid 3,570 lost-work days, 1,980 cases of respiratory and asthma symptoms, 3 - 28 non-fatal heart attacks, and 30 - 69 premature deaths for Illinois residents each year. The reported range of impacts reflects how different epidemiological studies have calculated different risk coefficients, each with their own error ranges.

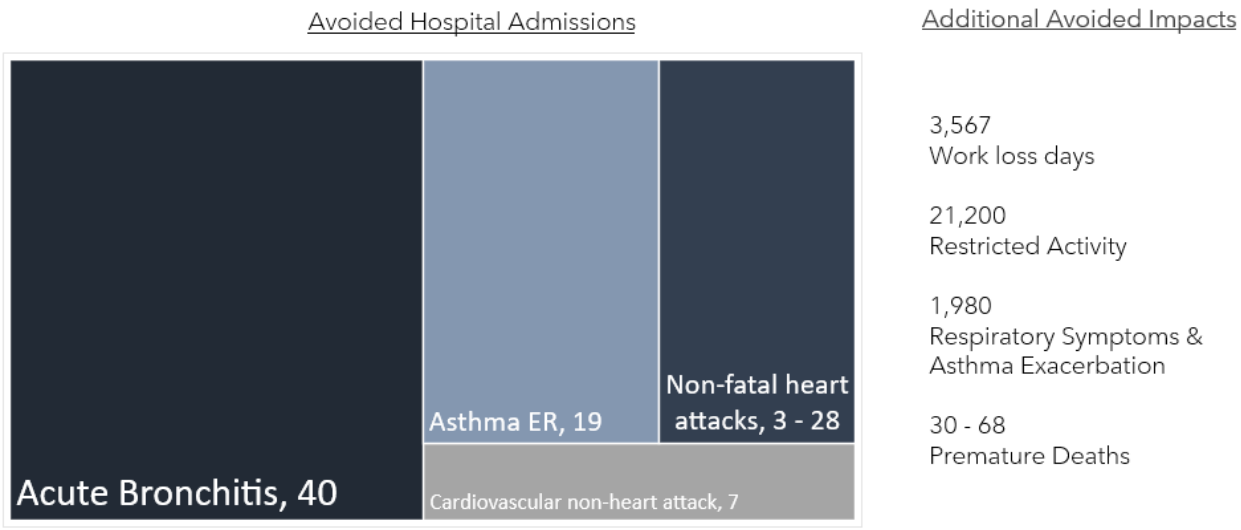

Figure 2. Average of COBRA-reported avoided hospital admissions and additional avoided impacts in modelled year.

The valuation of health impacts totals between $293 and $740 million in benefits for Illinois residents with additional benefits for other states impacted by emissions from Illinois. The benefits are widely distributed such that 90% of benefits occur across 40 counties in the state, as shown in Figure 3. Higher health benefits generally occur in more populous counties because more people benefit from improved air quality. All Illinois counties are shown to have positive health benefits as summarized in the listing of county-level health benefits included as Attachment 1.

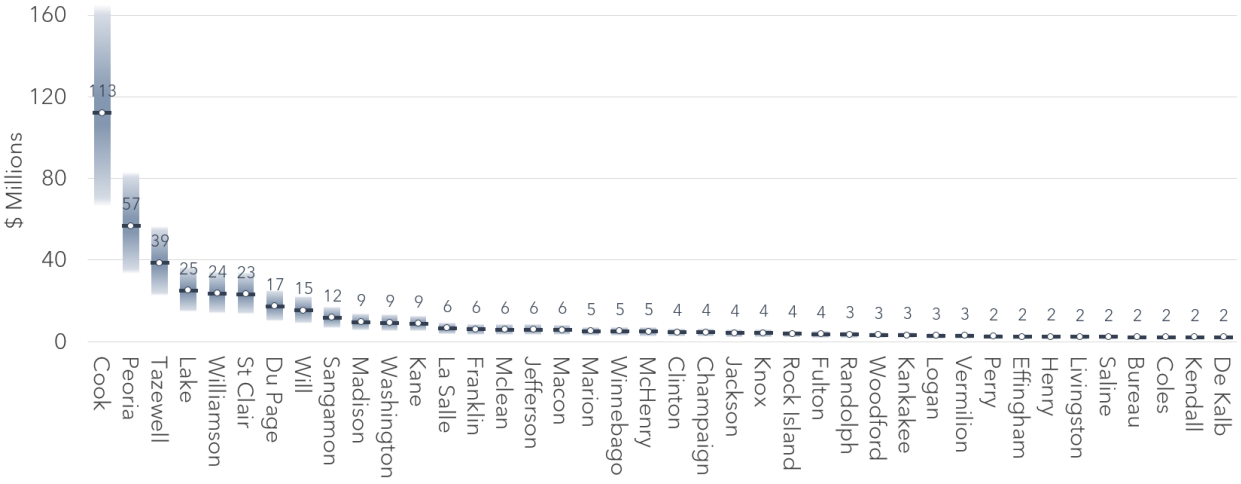

Figure 3. Average annual health benefits ($ Millions) for 40 counties with the highest COBRA-estimated annual health benefits resulting from a 100% carbon-free electricity sector.

Methodology

COBRA evaluates changes in air quality that occur relative to changes in a baseline emissions scenario. We modified COBRA's 2016 Baseline to incorporate 2019 reported power plant emissions of NO_x and SO_2 reported in the U.S. EPA's Clean Air Markets Database.[4] Emission estimates for power plant particulate matter ($PM_{2.5}$), volatile organic compounds (VOC), and ammonia NH_3 were generated using the 2016 COBRA-reported values scaled by the ratio of 2019 historic to 2016 COBRA Baseline NOx emissions. The proportion of power plant emissions relative to the statewide hybrid 2016/2019 emission inventory is illustrated in Figure 4.

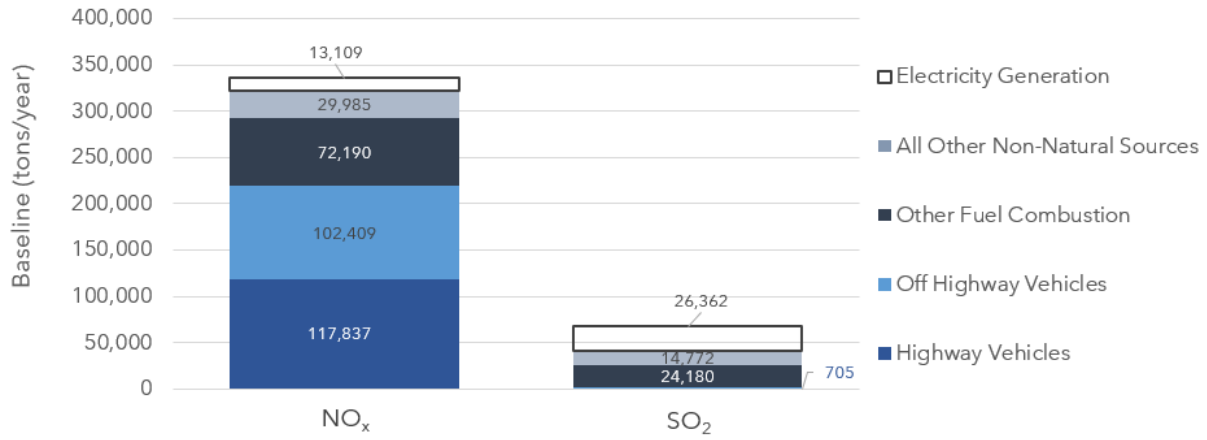

Figure 4. Illinois electricity-sector emissions comprised 4% of baseline NO_x and 39% of baseline SO_2.

To represent the potential impact of CEJA legislation, 100% of power plant emissions were subtracted from the COBRA emission scenario, representing 100% carbon-free electricity by 2030. To avoid over-crediting benefits to CEJA, the baseline inventory of power plant emissions excluded units that have retired since 2019 or have announced a pending retirement date according to EIA Electric Power Monthly or other company announcements.

Based on the emission source reductions described above, COBRA uses reduced-form modeling techniques to approximate atmospheric chemistry and transport and estimate improvements to county-level ambient $PM_{2.5}$ concentrations. COBRA then uses epidemiological concentration-response functions, derived from many studies, to translate the $PM_{2.5}$ concentration reductions into county-level health improvements. COBRA reports high and low estimates of premature death derived using two sets of assumptions reflecting low sensitivity and high sensitivity to ambient $PM_{2.5}$. Avoided non-fatal heart attacks are calculated based on from five studies. A summary of the health impact functions underlying COBRA impact estimates is included as Appendix C of the COBRA User's Manual.[2] Economic values reported here are the average of high and low estimates using both 3% and 7% default COBRA discount rates. COBRA Version 4 financial benefit results are reported in 2017 dollars.

Attachment 1 - County-Level Air Quality Improvement and Demographic Data

County	$PM_{2.5}$ ug/m^3 Reduction	Health Benefits Low Estimate	Health Benefits High Estimate	Population*	% NonWhite**
Adams	0.016	$682,269	$1,723,770	66,085	6.9%
Alexander	0.041	$219,723	$555,062	6,260	37.6%
Bond	0.102	$950,157	$2,402,640	16,589	9.1%
Boone	0.021	$504,417	$1,275,016	53,537	12.6%
Brown	0.021	$65,509	$166,562	6,628	22.6%
Bureau	0.056	$1,199,967	$3,035,282	33,122	6.4%
Calhoun	0.014	$43,390	$109,665	4,830	2.4%
Carroll	0.018	$190,979	$482,999	14,466	4.3%
Cass	0.048	$405,776	$1,025,414	12,493	10.1%
Champaign	0.036	$2,560,074	$6,475,812	209,922	27.7%
Christian	0.046	$1,036,095	$2,626,609	32,931	3.4%
Clark	0.037	$422,324	$1,067,651	15,716	3.0%
Clay	0.049	$436,604	$1,103,804	13,287	2.3%
Clinton	0.129	$2,585,701	$6,545,045	37,634	6.4%
Coles	0.042	$1,163,541	$2,944,616	51,353	7.2%
Cook	0.029	$65,357,647	$165,105,456	5,198,275	43.4%
Crawford	0.031	$392,080	$992,657	18,972	9.2%
Cumberland	0.044	$277,207	$700,767	10,836	2.6%
DeKalb	0.028	$1,125,880	$2,839,023	104,366	15.7%
DeWitt	0.061	$628,080	$1,587,032	15,932	3.8%
Douglas	0.041	$466,279	$1,178,438	19,623	3.7%
DuPage	0.028	$9,998,642	$25,208,653	929,060	22.5%
Edgar	0.037	$513,556	$1,298,109	17,407	2.3%
Edwards	0.034	$144,447	$365,149	6,455	3.0%
Effingham	0.064	$1,309,908	$3,307,496	34,137	2.7%
Fayette	0.092	$1,085,165	$2,749,819	21,565	6.3%
Ford	0.040	$442,238	$1,117,666	13,270	4.6%
Franklin	0.114	$3,464,282	$8,749,037	38,923	3.0%
Fulton	0.082	$2,037,565	$5,153,660	35,092	5.7%
Gallatin	0.051	$227,861	$575,705	5,064	3.3%
Greene	0.023	$188,480	$476,419	13,132	3.0%
Grundy	0.033	$748,957	$1,893,256	50,666	6.3%
Hamilton	0.088	$544,608	$1,375,726	8,176	2.2%
Hancock	0.021	$257,524	$650,783	17,983	2.6%
Hardin	0.050	$164,602	$415,946	3,939	4.6%
Henderson	0.031	$156,443	$395,569	6,809	2.2%
Henry	0.043	$1,276,714	$3,228,597	49,267	5.9%
Iroquois	0.034	$711,056	$1,796,300	27,812	7.2%
Jackson	0.092	$2,405,788	$6,103,163	57,977	23.3%
Jasper	0.038	$235,223	$594,517	9,594	2.6%
Jefferson	0.129	$3,336,458	$8,437,648	37,985	12.4%
Jersey	0.017	$239,469	$605,599	21,937	3.3%
Jo Daviess	0.014	$198,907	$502,921	21,588	2.9%
Johnson	0.063	$455,969	$1,154,050	12,494	12.6%
Kane	0.028	$5,085,205	$12,788,760	531,376	27.4%
Kankakee	0.029	$1,754,954	$4,429,087	110,637	20.3%
Kendall	0.034	$1,156,139	$2,897,212	126,054	17.7%
Knox	0.061	$2,362,765	$5,971,403	50,508	14.1%
Lake	0.056	$14,584,135	$36,794,315	701,473	22.7%
LaSalle	0.051	$3,712,143	$9,391,465	109,737	6.8%
Lawrence	0.028	$300,763	$761,703	16,033	13.0%
Lee	0.031	$638,932	$1,627,000	34,389	9.6%
Livingston	0.052	$1,241,977	$3,139,346	36,040	7.1%

Attachment 1 –Continued

County	$PM_{2.5}$ ug/m^3 Reduction	Health Benefits Low Estimate	Health Benefits High Estimate	Population*	% NonWhite**
Logan	0.087	$1,646,394	$4,163,367	29,003	11.6%
McDonough	0.037	$600,750	$1,522,208	30,479	9.7%
McHenry	0.023	$2,778,280	$7,018,640	307,714	7.6%
Mclean	0.051	$3,355,622	$8,454,009	172,578	17.0%
Macon	0.047	$3,254,600	$8,226,643	105,528	22.0%
Macoupin	0.034	$1,077,870	$2,726,306	45,463	3.1%
Madison	0.035	$5,474,979	$13,898,719	264,776	12.5%
Marion	0.105	$2,865,888	$7,264,104	37,743	7.4%
Marshall	0.102	$908,368	$2,295,264	11,679	2.7%
Mason	0.069	$701,362	$1,772,970	13,621	2.8%
Massac	0.060	$689,316	$1,742,683	14,219	9.0%
Menard	0.060	$477,103	$1,205,783	12,306	2.8%
Mercer	0.025	$267,349	$675,640	15,589	3.0%
Monroe	0.037	$643,718	$1,626,807	34,168	2.3%
Montgomery	0.046	$932,698	$2,359,917	28,828	6.7%
Morgan	0.038	$841,860	$2,130,418	34,247	9.7%
Moultrie	0.043	$448,502	$1,133,217	14,641	2.0%
Ogle	0.027	$783,817	$1,983,219	51,025	5.8%
Peoria	0.333	$33,025,959	$83,291,603	182,770	27.1%
Perry	0.107	$1,432,542	$3,627,983	21,251	11.8%
Piatt	0.044	$457,236	$1,155,789	16,401	2.9%
Pike	0.018	$204,701	$517,628	15,672	3.2%
Pope	0.052	$140,809	$356,287	4,203	8.0%
Pulaski	0.048	$219,574	$555,260	5,510	34.5%
Putnam	0.065	$222,752	$563,439	5,721	3.0%
Randolph	0.093	$1,919,894	$4,871,757	32,295	13.0%
Richland	0.036	$420,644	$1,063,309	15,766	3.6%
Rock Island	0.024	$2,149,515	$5,424,373	143,873	19.1%
St. Clair	0.097	$13,426,827	$34,038,287	262,338	35.9%
Saline	0.063	$1,227,042	$3,099,804	23,994	7.2%
Sangamon	0.064	$6,822,210	$17,242,782	196,861	18.1%
Schuyler	0.040	$177,329	$448,269	6,953	9.0%
Scott	0.026	$89,643	$226,539	5,005	1.8%
Shelby	0.048	$646,169	$1,633,981	21,737	1.7%
Stark	0.093	$420,804	$1,063,074	5,447	2.7%
Stephenson	0.015	$445,369	$1,126,710	45,093	14.0%
Tazewell	0.284	$22,424,857	$56,546,499	133,195	4.2%
Union	0.073	$952,392	$2,409,441	16,968	5.9%
Vermilion	0.029	$1,579,343	$3,985,582	77,563	17.7%
Wabash	0.033	$260,433	$658,598	11,546	3.8%
Warren	0.036	$374,004	$945,119	17,146	11.9%
Washington	0.584	$5,320,788	$13,434,127	14,058	3.3%
Wayne	0.064	$780,005	$1,970,867	16,402	3.3%
White	0.036	$438,725	$1,108,266	13,868	2.1%
Whiteside	0.023	$870,159	$2,201,945	56,016	6.6%
Will	0.035	$8,878,424	$22,395,549	689,315	26.6%
Williamson	0.320	$13,625,856	$34,429,853	67,102	8.7%
Winnebago	0.018	$2,855,372	$7,241,240	284,819	21.0%
Woodford	0.081	$1,788,285	$4,517,856	38,700	3.2%
Total		**293,040,713**	**740,251,133**	**12,770,631**	

*https://www.illinois-demographics.com/counties_by_population
** U.S. Census Bureau. American Community Survey (2014-2018).

Acknowledgement

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