Electricity and Air Quality in the Eastern U.S.

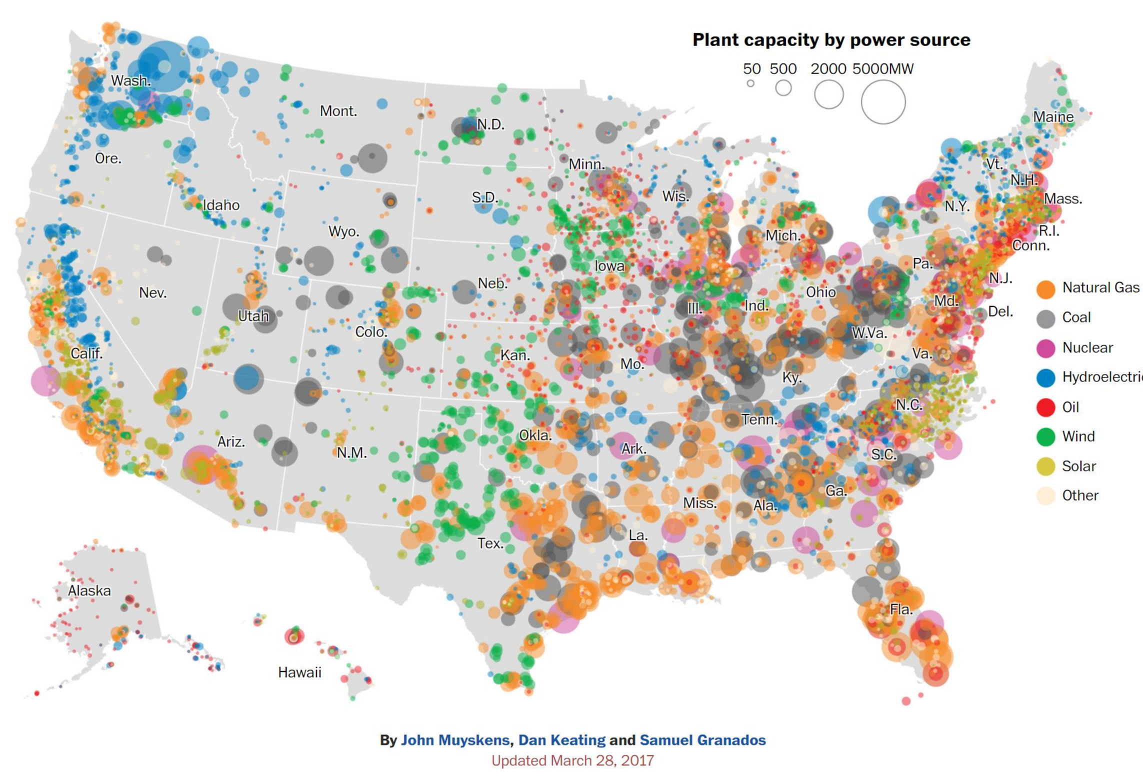
David Abel[1], Tracey Holloway[1], Monica Harkey[1]

Electricity Emissions and Temperature: Paul Meier[4], Ryan Kladar[1], Doug Ahl[5], Scott Schuetter[5], Jonathan Patz[6]

Solar and Air Quality: Arber Rrushaj[1], Phillip Duran[1], Paul Denholm[2], Greg Brinkman[2], Mark Jannsen[3]

1. Nelson Institute Center for Sustainability and the Global Environment (SAGE), University of Wisconsin – Madison
2. National Renewable Energy Laboratory (NREL), Golden, CO
3. Lake Michigan Air Directors Consortium (LADCO), Chicago, IL
4. Wisconsin Energy Institute (WEI), University of Wisconsin – Madison
5. Seventhwave, Madison, WI
6. Global Health Institute, University of Wisconsin - Madison

Introduction



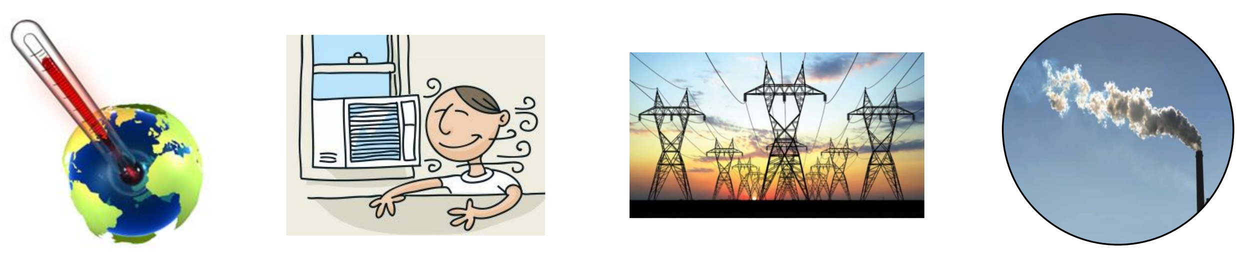
This work explores the relationship between the electricity sector and air quality in the Eastern U.S. through two distinct studies:

1. The relationship between power plant emissions and ambient temperature.
2. The air quality benefits of incorporating solar energy.

The location and type of each power plant in the U.S. is shown in the figure above[4]. The Eastern U.S. has a high concentration of both people and fossil-fuel power plants making air quality improvements from power plants in this region especially beneficial to human health and well-being.

Findings highlight the potential for renewable energy and energy efficiency to support current and future air quality regulations and improve human health. They also show the co-benefits to air quality and health of these measures incorporated in policy for climate change mitigation. Finally, these studies address the gap in collaboration between energy and air quality planning, such as in State Implementation Plans[6], as well as a lack of tools and methodology for integrated analysis across fields.

Electricity Emissions and Temperature[2,3]

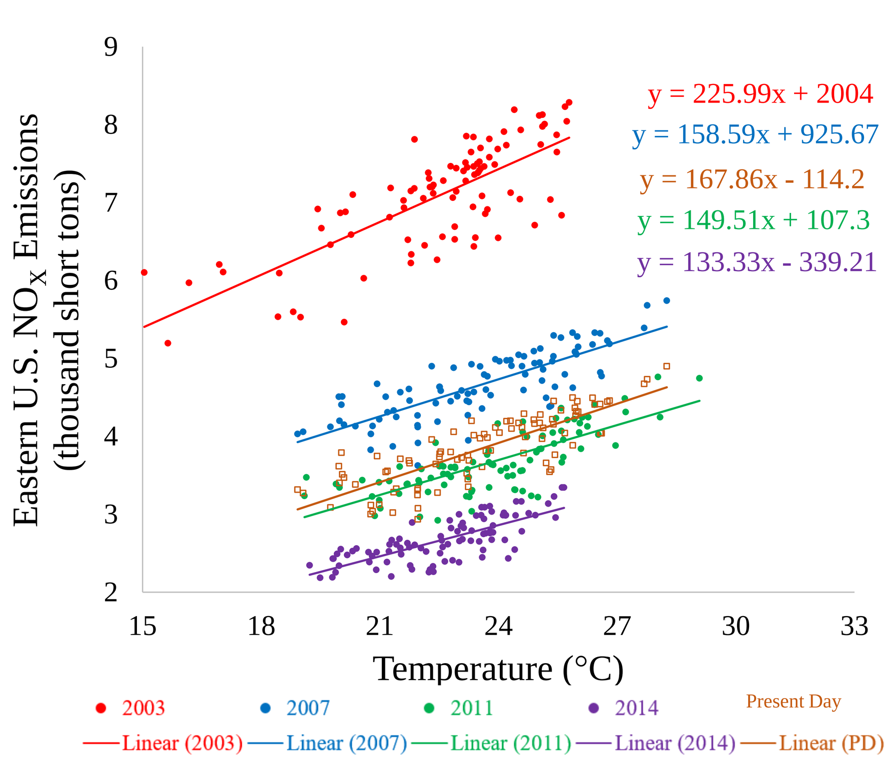


2007 NARR Climate Data	Demand Modeled in Regional Building Energy Simulation System (RBESS)	Electricity Simulated with the MyPower Dispatch Model	Emissions Simulated with the MyPower Dispatch Model	Air Quality Modeled with Community Multiscale Air Quality Model (CMAQ)	Health Impacts Modeled with Environmental Benefits and Mapping and Analysis Program (BenMAP)
2069 NARCCAP Climate Data					

What is the relationship between electricity-sector emissions and daily average ambient temperature?

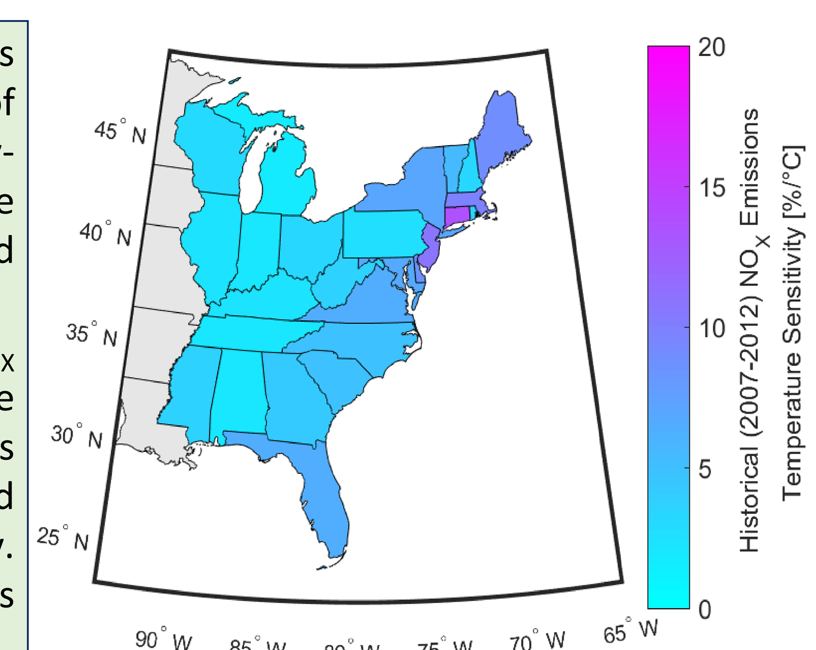
It is well known that higher temperatures lead to increased air conditioning use in buildings, which comprise 72% of electricity demand[5]. This in turn necessitates additional electricity production and increases electricity sector emissions. A statistical analysis of historical monitoring data is used to quantify the sensitivity of power plant emissions to temperature, and an integrated modeling methodology, as shown above, is used as a comparison.

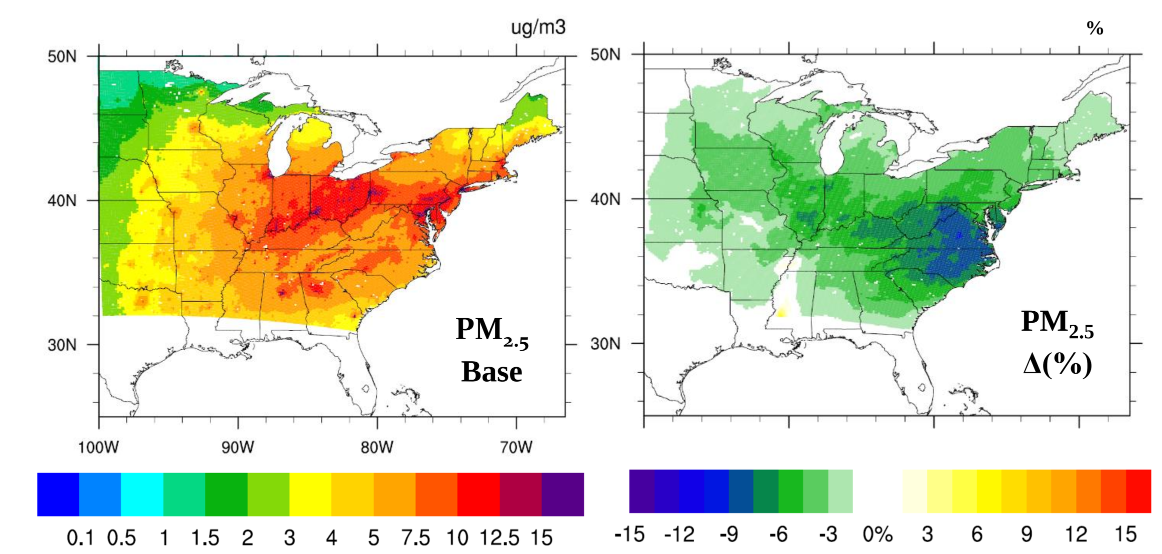
Key results show that regionally, a 1°C increase in temperature results in increases in SO_2 emissions of 3.17%, NO_X increases by 3.54%, CO_2 by 3.32%, and electricity generation, 3.87%.



Historical sensitivity of power plant emissions to temperature is represented by the slope of linear regression performed yearly, and state-by-state comparing average daily temperature at the centroid of each state to emissions of SO_2, NO_X and CO_2 from power plants within that state.

Regionally, this relationship is shown for NO_X emissions in the figure to the left. The orange line represents the simulated comparison. This simulation matches historical emissions data and sensitivity extremely well, a key takeaway. Additionally, spatial variation in sensitivity follows expected patterns as seen in the figure to the right.





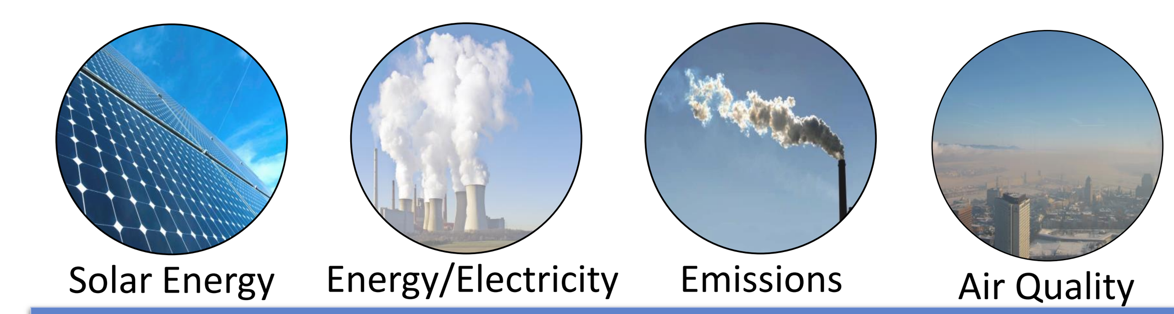
What are the air quality impacts of integrating solar energy into the electricity grid?

This study is a retrospective analysis incorporating economic dispatch electricity models, national emissions inventory, a three-dimensional Eulerian photochemical transport model, and comparison with measurements as described in the top right figure.

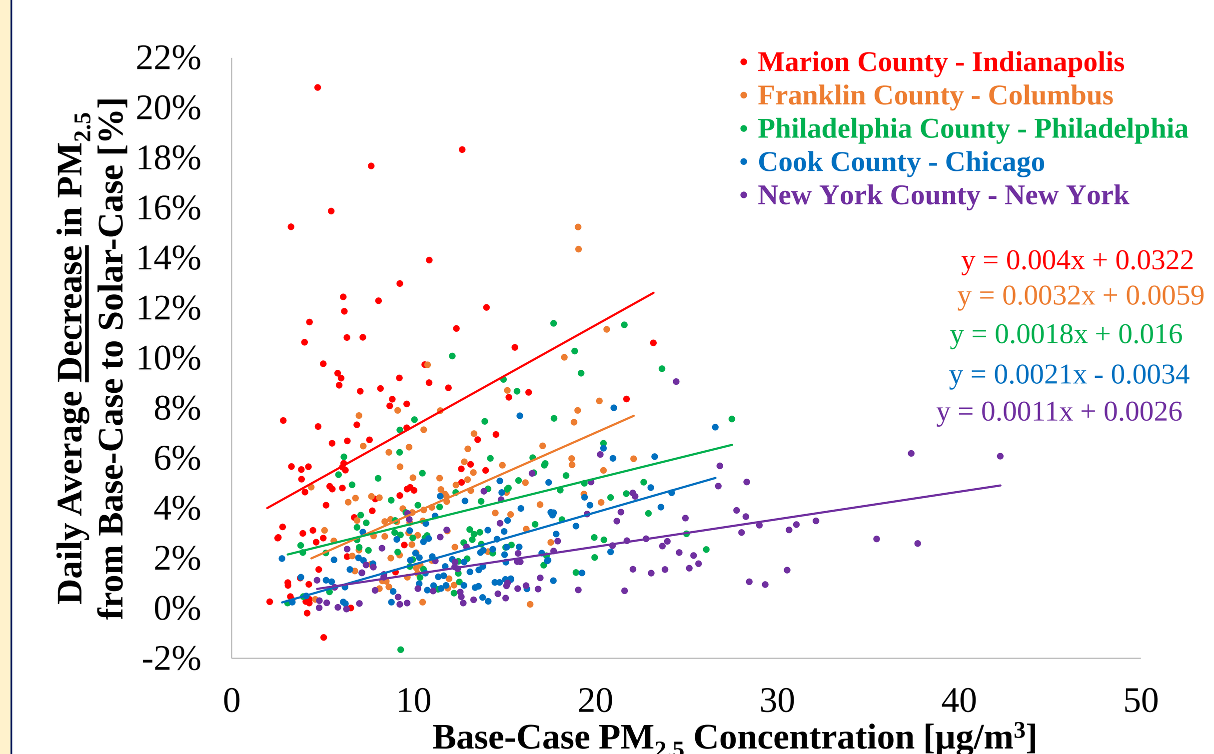
Key results show that electricity sector emissions decreases are similar to the amount of solar energy incorporated, with NO_X decreasing more than SO_2. The figure above shows average summer $PM_{2.5}$ concentrations for base conditions and the difference with the addition of solar. On average, regional $PM_{2.5}$ decreases 4.7% with 17% solar photovoltaics.

Additionally, in cities (where standards are most difficult to achieve), the worst air quality days see the greatest improvement. This is shown in the figure to the right where base-case $PM_{2.5}$ concentrations are plotted against the proportional decreases seen with the addition of solar. This highlights the potential air quality co-benefits of climate policy incorporating renewable energy, but also the benefits of incorporating renewable energy and energy efficiency in State Implementation Plans to achieve clean air standards.

Solar Energy and Air Quality[1]



2006 Conditions	2006 Normal Conditions as modeled in GridView at NREL	2007 National Emissions Inventory provided by LADCO	$PM_{2.5}$ average concentration of 4.7 μg/m³ modeled in CMAQ
17% Solar Energy	Proposed Conditions modeled in GridView at NREL	Proposed results show 15-20% lower emissions of SO_2 and NO_X	4.7% lower $PM_{2.5}$ concentrations



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Public data sources:
Energy Information Administration
U.S. Environmental Protection Agency's Clean Air Markets Database
U.S. Environmental Protection Agency's Air Quality System Datamart
National Oceanic and Atmospheric Administration's North American Regional Reanalysis data

Holloway Research Group – University of Wisconsin

Contact Information:

David Abel:
Center for Sustainability and the Global Environment (SAGE), Nelson Institute for Environmental Studies, University of Wisconsin – Madison, Madison, WI 53726
Website: www.sage.wisc.edu **Email:** dwabel@wisc.edu