Photo from iStock 1394392205

Clean Energy Co-Benefits: Air Quality, Health and Just Energy Transitions

The National Renewable Energy Laboratory (NREL) conducts high-impact analyses with international partners to further decarbonization strategies, just energy transitions, and sustainable development goals

Outdoor air pollution is a leading environmental risk factor and contributes to over four million deaths per year, making it the fourth leading cause of death globally[1]. However, in many regions, air quality is worsened by fossil fuel combustion from all economic sectors: power, transportation, industry, agriculture, buildings, and more. This contributes to decreased quality of life, increased government expenditures, and decreased economic activity, driving governments, civil society, and industry leaders to seek solutions.

A variety of air pollutants contribute to decreased air quality. Fine particulate matter ($PM_{2.5}$), ozone, sulfur dioxide, nitrogen oxides, lead, and other toxins are all mixed in the air we breathe in some concentration everywhere in the world. Some pollutants are directly emitted, while others are formed in the atmosphere. Of these pollutants, $PM_{2.5}$ and ozone, both formed in the atmosphere, are the greatest global health burden. Once pollutants are emitted or formed in the atmosphere, there is no practical solution to reduce their concentration. The only way to limit their concentration is through reducing emissions.

The benefits of improving air quality are tangible, immediate, and monetizable—especially when considered in combination with other benefits of clean energy transitions such as decarbonization, environmental justice, and achieving sustainable development goals.

[1] GGBD 2016 Risk Factors Collaborators. (2017). "Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016." Lancet 390, no. 10100 (2017): 1345. https://doi.org/10.1016/S0140-6736(17)32366-8.

To facilitate a better understanding of the potential for, and benefits of, air quality improvements, the U.S. Agency for International Development (USAID) and NREL Partnership supported research projects around the world by using the Global Intervention Model for Air Pollution (Global InMAP). This model offers a new approach to estimating the human health impacts caused by air pollutant emissions and how those impacts are distributed across populations.

Types of Air Quality Analyses: Two Main Approaches

Researchers typically take one of two main approaches to analyzing air quality: measurement or modeling. To gain a baseline understanding of current air pollutant concentrations, measurements must be taken. There are many ways to measure concentration, even for the same pollutant. However, researchers must be conscious when choosing measurement instruments and sampling methods, designing measurement networks (number, time, and space), and discerning the value of one-time measurements vs. continuous or periodic, etc. All measurements are associated with the time and place they were taken, but generally, they do not identify sources. Significant effort must be expended to determine markers of specific sources and

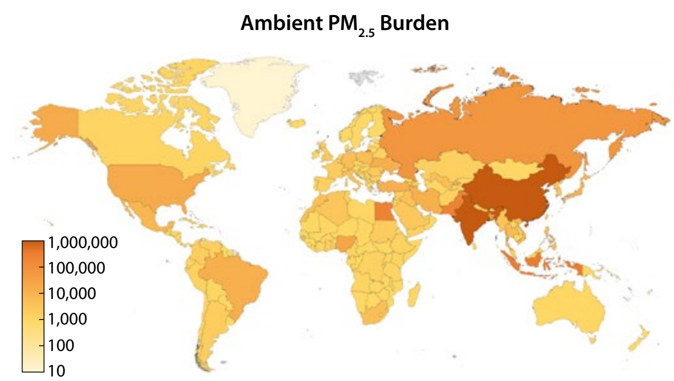

Figure 1. Country-level annual deaths attributable to outdoor (ambient) concentration of PM 2.5 *(modified from McDuffie et al. 2021)*

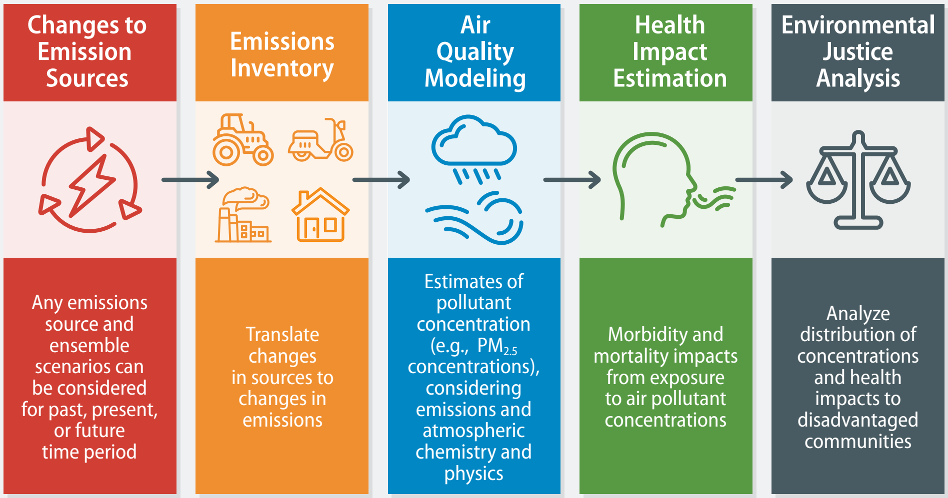

Figure 2. All of the steps inherent to modeling air quality, health effects, and the demographic distribution of both of those outcomes *(Graphic by NREL)*

An emissions inventory is a required input for any air model—the who, what, when, and how much of air pollutants—and typically depends on desired or potential changes to emission sources. What makes the Global InMAP model unique is that it directly combines health impact estimation into the model (which typically is performed as a separate analysis or model) and can process large numbers of cases or scenarios, owing to its highly efficient computational design. As an additional step that the USAID-NREL Partnership performed successfully in various projects, the geospatial and demographic analysis of results can be used in environmental justice (or just energy transition) analyses.

analyze measurement results to estimate source contributions (e.g., source apportionment analyses).

An air quality model is required to understand the potential future change to air pollutant concentrations and the resulting health effects, as well as distribution of those health effects across demographic groups. Modeling can also inform understanding of current air quality by differentiating the relative importance of sources and can be much less expensive than measurements.

The Value of Global InMAP and Other Air Quality Models

The InMAP model was originally developed to analyze the human health impacts caused by air pollutant emissions in the United States. Further research by the University of Minnesota, supported by NREL and the U.S. Department of State, later expanded this model to the Global InMAP model, which is designed to be applicable around the world.

The USAID-NREL Partnership led the first collaborative research using the Global InMAP model to quantify the impacts of renewable electricity deployment on air quality and human health in Southeast Asia. Global InMAP is a first-of-its kind global air quality model that can be used by stakeholders to apply findings to public health and environmental analysis, development strategies, and policy formation. Trainings were developed to democratize air quality modeling as part of capacity building activities with international partners. The USAID-NREL Partnership can collaboratively use the model to provide insights into the intersection of clean energy transitions, air quality, and public health.

One benefit of the Global InMAP model is that it can model air quality and health changes for any type of source at multiple spatial scales (global, regional, national, and sub-national). However, there are some circumstances in which the policy or research question is specific to one source or source type and a user may be interested in even finer spatial resolution than Global InMAP's 4-km resolution.

In these cases, source-specific models can be used. For instance, a point-source-specific model can be applied to understand the impacts of fuel substitution (or retirement) of a power plant. In another example, electrification of vehicles within a metropolitan area can be studied with a line-source-specific model. NREL's experience with these source-specific air quality models can inform decisions about when it would be beneficial to understand finer-scale concentration and exposure changes.

By using models to analyze air quality and health impacts, governments, civil society organizations, and other stakeholders can better understand complex relationships among clean energy integration, public health, and just energy transitions. Air pollution continues to be a pervasive issue around the world, contributing to millions of deaths each year. With these cutting-edge tools, it is possible to find solutions and better understand the valuable connections between clean energy and public health.

Learn more about how to work with NREL on understanding the air quality and public health impacts of clean energy transitions.

Contact Us:

Sadie Cox, International Partnerships Manager
Sadie.Cox@nrel.gov

NREL Transforming ENERGY

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL prints on paper that contains recycled content.

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

NREL/FS-6A20-85554 • April 2023