# Electricity source determines benefits of electrifying China's vehicles

February 17 2021

Credit: CC0 Public Domain

Each year an estimated 1.2 million Chinese citizens die prematurely due to poor air quality. And public health consequences are particularly dire during extreme air quality events, such as infamous "Airpocalypse"

winter haze episodes.

A team of Northwestern University researchers wondered if widespread adoption of electric vehicles (EVs) could help China avoid these deadly events. The answer? It depends.

In a new study, the researchers concluded air quality and public health benefits of EVs—as well as their ability to reduce carbon emissions—in China are dependent on the type of transport electrified and the composition of the electric grid.

The study was published today (Feb. 16) in the February 2021 issue of the journal *Earth's Future*.

"A significant fraction of China's electricity is currently sourced from the burning of coal, which is a very carbon intensive power source," said Jordan Schnell, the study's lead author. "When the coal-heavy power is used to charge light-duty vehicles, carbon emissions are reduced because of the efficiency of light-duty EVs. Heavy-duty electric vehicles require significantly more energy, so we see a net increase in carbon dioxide emissions. However, even when heavy-duty vehicle power is sourced entirely by coal-fired electricity, we still see air quality improvements because the on-road emission reductions outweigh what the power plants add. Fine particulate matter emissions, which are a main ingredient in haze, are reduced."

"We find that to achieve net co-benefits from heavy-duty EV adoption, the real sticking point in China's infrastructure lies in its power-generation sector. Greater adoption of emission-free renewable power generation is needed," said Northwestern's Daniel Horton, the study's senior author. "For light-duty vehicles the co-benefits are already there under the current infrastructure."

Horton is an assistant professor of Earth and planetary sciences in Northwestern's Weinberg College of Arts and Sciences. At the time of the research, Schnell was a postdoctoral fellow in Horton's laboratory. He is now a research scientist at the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder.

Pollutants come from a variety of sources, both natural and human-caused, and include emissions from transportation and power-generation facilities. Adoption of EVs reduces the emission of air pollutants and greenhouse gases from vehicle tailpipes, but the overall emissions budget must account for the shifting of emissions to the power plants used to charge EV batteries. Country-wide vehicle distribution and energy consumption also play roles in overall emissions profiles. Heavy-duty versus light-duty vehicles, for example, differ substantially, complicating the net outcome.

To reconcile these complicating factors, the researchers combined chemistry-climate modeling with emissions, weather and public health data. The researchers examined the air quality and climate benefits and tradeoffs of heavy-duty versus light-duty vehicle adoption using meteorological conditions from a notorious Airpocalypse event in January 2013. Unlike previous EV-air quality studies that focused on chronic exposure, the researchers focused on the acute public health impacts of exposure to this short, but extremely hazardous, haze event.

The researchers discovered that EV adoption could have a modest role in reducing the public health burden of individual Airpocalypse events, with the extent depending on the type of vehicle electrified. They also found the realization of public health and climate co-benefits depended on the addition of emission-free renewable energy to the electric grid.

During the January 2013 extreme pollution episode, poisonous haze hung over much of China, including the major population centers of

Beijing, Tianjin and Hebei. Acute exposure to the record-high levels of fine particulate matter and nitrogen dioxide increased pollution-related respiratory diseases, heart disease and stroke, which the researchers estimate led to approximately 32,000 premature deaths and $14.7 billion in health care costs.

To assess the consequences of EV adoption, in one model simulation scenario the researchers replaced roughly 40% of China's heavy-duty vehicles (such as construction equipment, long-haul trucks and buses) with electrified versions. An alternative scenario simulated the replacement of roughly 40% of China's light-duty vehicles with electric alternatives. The energy needed to charge the EV batteries is equivalent in both scenarios and is sourced from power-generation facilities on the grid. Emissions of greenhouse gases and air pollutants are determined according to the battery-charging load and power plant profile.

The research team found that electrifying 40% of heavy-duty vehicles consistently improved air quality—avoiding up to 562 premature deaths. It did not, however, reduce greenhouse gas emissions. Light-duty EV adoption, on the other hand, reduced carbon dioxide emissions by 2 megatons but had more modest air quality benefits.

To drive home this point, the researchers provided an additional scenario comparison. When all traffic emissions are removed from the 2013 event, air quality improvements lead to a 6% decrease in acute premature mortality. When all power-sector emissions are removed, however, acute premature mortality declines 24%.

"Overall, we found that EV-induced pollution changes and avoided premature deaths were modest for the extreme event," Schnell said. "But air quality will improve more drastically as the power-generation sector moves away from fossil fuel-fired electricity."

**More information:** J.L. Schnell et al, Potential for electric vehicle adoption to mitigate extreme air quality events in China, *Earth's Future* (2020). DOI: 10.1029/2020EF001788

Provided by Northwestern University