Toxic Air Pollution as a Sustainability Challenge

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The fundamental challenge of sustainability is to maintain and improve human well-being for present and future generations. Countries of the world agreed on seventeen Sustainable Development Goals (SDGs) in 2015 to guide such efforts until the year 2030 *(1)*. The seventeen SDGs include, among others, goals focusing on good health and well-being, affordable and clean energy, life on land, and reduced inequality. Climate action, one of the goals, is linked to many of the others: a recent paper argued that combatting climate change can be synergistic with all seventeen goals, but also introduce trade-offs with twelve others *(2)*. Informing more effective efforts to address complex, linked sustainability issues such as climate change requires understanding not only the environment, but also the human and technological drivers that affect and are affected by it, and the institutions and policies that shape decision-making.

I illustrate in this talk how engineering-based research can help understand the physical and societal links between policy actions and their ultimate impacts on people and their health and well-being. I use the example of climate change and air pollution to illustrate the potential of new systems-focused frameworks and modeling approaches to address sustainability challenges. Outdoor air pollution is a worldwide challenge: exposure to fine particulate matter ($PM_{2.5}$, aerosols ≤ 2.5 μm in size) and ozone causes millions of premature mortalities every year, and toxic air pollutants such as mercury pose risks to humans and the environment worldwide. Air pollution is also closely linked to the climate challenge: one study recently estimated that emissions related to fossil fuel burning account for 65% of air pollution-related premature mortalities *(3)*.

I will first discuss how integrating models of the economy and the atmosphere can help decision-makers assess the air pollution and related health impacts of proposed actions to mitigate carbon emissions. This will be drawn from research on China and the United States. For China, we showed that actions to mitigate climate change consistent with goals under the Paris Agreement can have air quality benefits that partially or fully offset the costs of the policies *(4)*. For the U.S., we showed that state- and regional-level efforts to mandate renewable energy can have near-term benefits for air quality that also exceed policy costs *(5)*.

Second, I will show how novel approaches can assist decision-makers in understanding the implications of different strategies, in particular their costs and benefits over space and time. Actions to mitigate climate change in China, for example, have different implications in different regions of the country *(4)*, and can also substantially benefit human health in South Korea, Japan, and the United States *(6)*. Policy-makers considering air pollutants such as mercury may benefit from using simple metrics that help account for longer-term impacts *(7)*.

Finally, building on calls for scientists and engineers to develop more useful knowledge to inform sustainable development *(8)*, I will discuss how effectively informing the design of solutions also requires interactions with decision-makers. I will describe ways in which I have incorporated public and policy engagement in my work, and examine how research on air pollution, toxic substances, and climate more broadly has influenced decision-making. Such engagement resonates strongly with an engineering-driven focus on real-world impact.

References:

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