RESOURCES *for the* FUTURE

Carbon Pricing 105: Effects on Human Health

Explainer by **Marc Hafstead** — May 2020

1. Introduction

Carbon pricing is a climate policy approach that charges emitters of carbon dioxide (CO_2) for each ton they are responsible for emitting, increasing the price of all products that cause CO_2 emissions. Carbon pricing policies cause a decrease in the combustion of fossil fuels, which is a significant source of local air pollution. This explainer describes the human health benefits of decreased air pollution due to carbon pricing..

Carbon Pricing Explainer Series

This explainer is part of RFF's Carbon Pricing Explainer Series, which outlines the fundamentals of carbon pricing policy from what it is to how it affects people and the economy.

- **Carbon Pricing 101**
- **Carbon Pricing 102: Revenue Use Options**
- **Carbon Pricing 103: Effects across Sectors**
- **Carbon Pricing 104: Economic Effects across Income Groups**
- **Carbon Pricing 105: Effects on Human Health**
- **Carbon Pricing 106: Effects on Employment**
- **Carbon Pricing 201: Pricing Carbon in the Electricity Sector**
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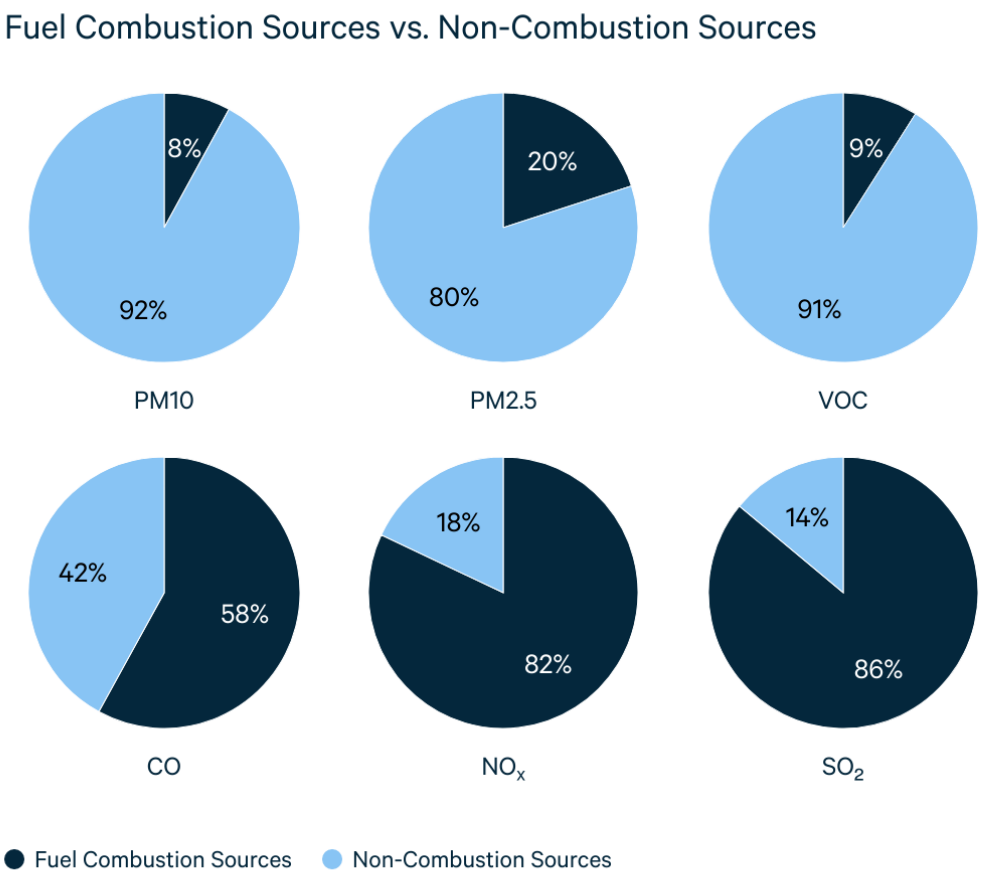
- **Carbon Pricing 301: Advanced Topics in Carbon Pricing in the Electricity Sector**

2. Carbon Pricing Benefits: Climate vs. Health

The climate benefits of reducing greenhouse gas emissions are often disconnected from the firms and households reducing emissions in both space and time. Avoided damages from mitigating emissions through policies such as a price on carbon are realized over many years into the future and throughout the globe; in other words, the climate benefits of reducing emissions today do not accrue to the people bearing the costs of those emissions reductions. These time- and space-disconnects are often **cited** as a reason why the climate challenge is so hard to tackle.

There are, however, large and immediate local benefits to human health that can occur from climate policies such as a carbon tax or a cap-and-trade program. The combustion of fossil fuels releases carbon dioxide into the atmosphere; in 2018, this source of emissions was responsible for over 75 percent of gross greenhouse gas emissions in the **United States**. The combustion of fossil fuels also gives rise to a number of local air pollutants, including carbon monoxide (CO), nitrogen oxide (NO_x), volatile organic compounds (VOCs), ammonia (NH_3), and particulate matter (PM10 and PM2.5). Each of these pollutants—termed **criteria air pollutants**—has been determined to be harmful to human health under the US Clean Air Act.

Figure 1. Criteria Air Pollutant Emissions



See Table 1 for data.

Source: **2014 National Emissions Inventory**

3. Air Pollution Sources

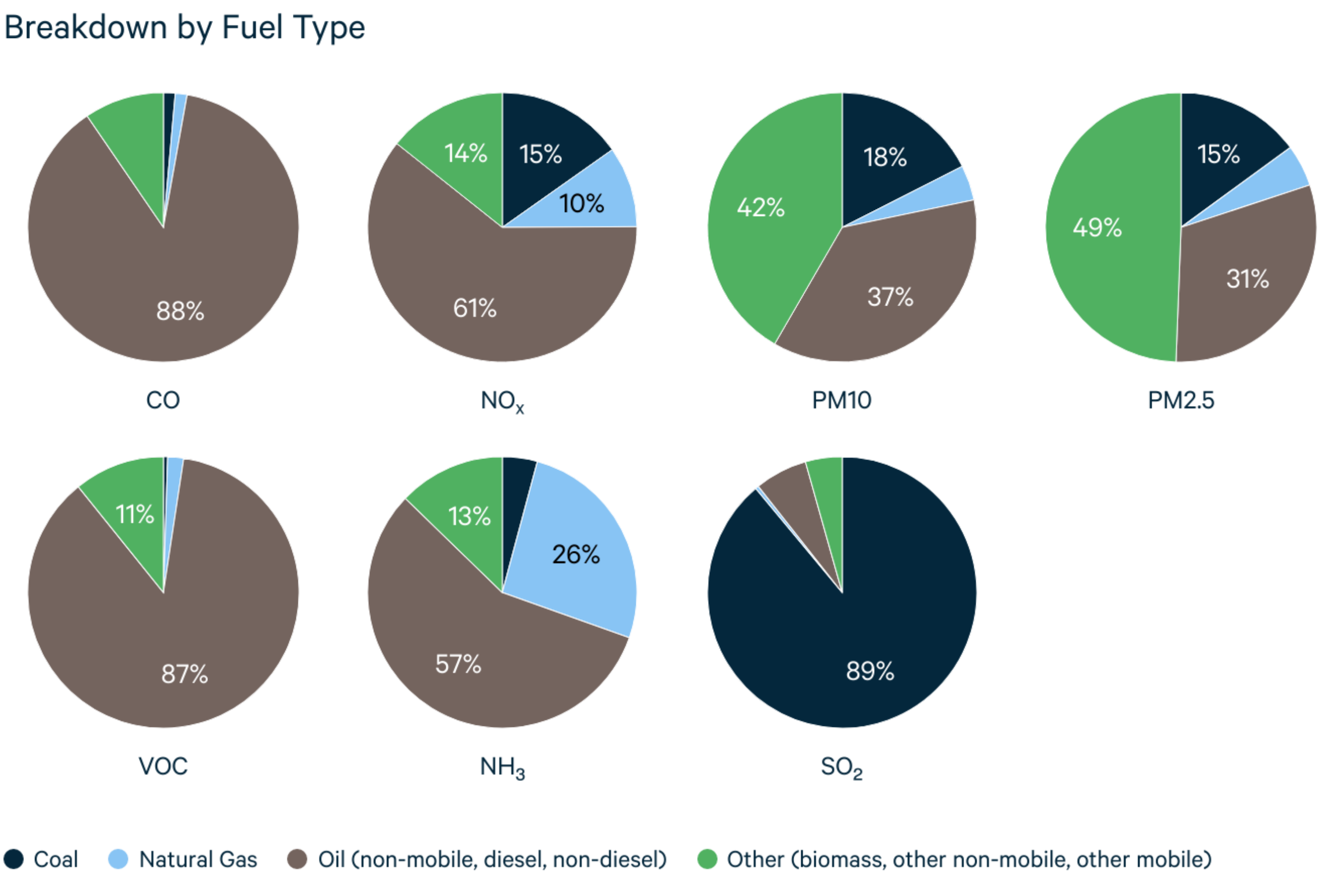
Figure 1 displays the different sources of these criteria air pollutants (CAP) from the **2014 National Emissions Inventory**. Fuel combustion is responsible for a majority of CO, NO_x, and SO_2 emissions. Non-combustion sources—agriculture (fertilizer, crop dust, livestock waste), dust (construction and road), fires, industrial processes, and other (solvents, waste disposal, gas stations and terminals commercial cooking, and biogenics)—are responsible for a majority of PM10, PM2.5, VOC, and NH_3 emissions.

Figure 2 displays the fuel sources of fuel combustion-related criteria air pollutants. On and off-road combustion of diesel and non-diesel fuels accounts for the majority of CO, VOC, and NH_3 fuel combustion CAP emissions whereas coal combustion is responsible for a vast majority of SO_2 emissions from combustion

4. The Effect of Carbon Pricing on Pollution

In addition to reducing CO_2 emissions, a carbon price reduces harmful criteria air pollutants from fuel combustion that harm human health. To demonstrate these effects, take this example of a theoretical carbon fee (from ***Confronting the Climate Challenge***). The theoretical carbon fee is $20 per metric ton in 2019 (in $2013) and rises at 4 percent annually; in 2030, the price

Figure 2. Fuel Combustion-Related Criteria Air Pollutant Emissions



See Table 2 for data.

Source: **2014 National Emissions Inventory**

is approximately $31 and in 2040 the price is about $45. Figure 3 displays the projected nationwide change in local air pollutant emissions.

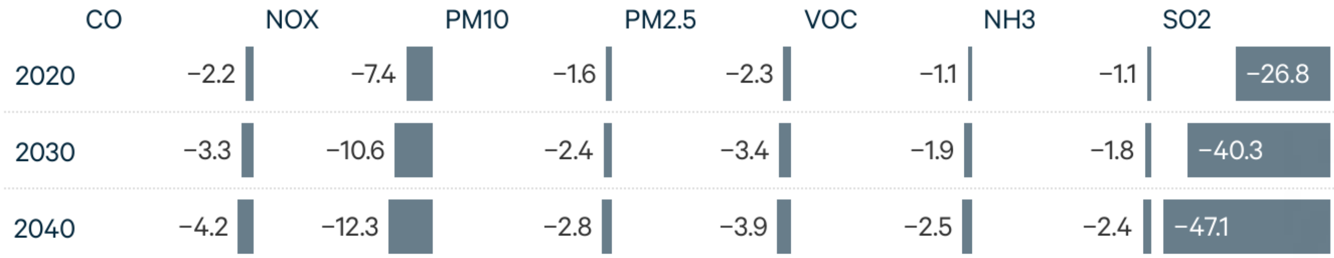
The price on carbon significantly reduces electricity generation from coal-fired power plants; as a result, SO_2 emissions are projected to decline substantially. NO_x emissions are also projected to decrease, primarily due to the decline in coal-fired electricity generation. The response in the emissions of CO, VOC, and NH_3 reflect the relatively small impact that modest carbon prices have on demand for transportation fuels.

5. Health Effects of Reduced Pollution

The precise health benefits of these air pollution reductions are difficult to quantify. The health impacts depend on the source and location of emissions, ambient air pollutant concentrations, and weather patterns that disperse the pollutants away from the source of emissions. Some regions will benefit more than others from changes in these CAP emissions—regions that currently have substantial coal-fired electricity generation are likely to benefit the most.

Figure 3. Criteria Air Pollutant Emissions Under Carbon Fee

Change in emissions of criteria air pollutants under a \$20-per-metric-ton carbon fee rising at 4% annually, relative to business-as-usual



Source: **Confronting the Climate Challenge (Goulder and Hafstead, 2017)**

5.1. Measuring Pollution Reduction Benefits

At the national level, the US Environmental Protection Agency (EPA) doesn't attempt to quantify the benefits of reducing CO, PM10, VOCs, and NH_3. However, EPA does calculate the **benefit per ton of reduced PM2.5 pollution** caused by both primary PM2.5 emissions and the PM2.5 precursors SO_2 and NO_X. For 17 sectors, the EPA approach uses source apportionment photochemical modeling to predict ambient air concentrations of PM2.5, SO_2, and NO_x and then maps the concentrations into human health impacts. Estimates of morbidity (non-fatal heart attacks, hospital admissions, lost workdays, asthma exacerbation, respiratory symptoms, etc) and mortality (infant and premature adult) are then used to estimate the benefit per ton based on the monetary value of the health impacts.

EPA uses mortality estimates from **Krewski et al. (2009)** to estimate the benefit per ton reduced of PM2.5. It finds that the benefits of pollutant reductions range from \$48,000 and \$523,000 for direct PM2.5 emissions, \$13,000 to \$427,000 for SO_2 reductions, and from \$2,000 to \$17,000 for NO_x reductions. (The values vary within these ranges, depending on the emissions source in question; all dollar values are in \$2015.) The EPA also presents estimates based on results from **Lepeule et al (2002)**; these estimates are about 2.2 times greater than those based on Krewski et al.

5.2. Health Benefits of a Theoretical Carbon Fee

With these benefit estimates and the projected reductions in CAPs under a carbon fee, the total benefits due to reduced mortality and morbidity associated with PM2.5 can be estimated (see ***Confronting the Climate Challenge***). For the sample carbon fee described above, the present value of the benefits are projected to be \$3.3 trillion, \$4.4 trillion, and \$0.7 trillion for reductions in PM2.5, SO_2 and NO_x emissions over time, respectively. Depending on the value used to estimate the climate benefits, the projected health benefits may even exceed the estimated climate benefits for this theoretical policy.

Table 1. Breakdown of Criteria Air Pollutants by Source

	CO	NO_x	PM10	PM25	SO_2	VOC	NH_3
Agriculture	0%	0%	22%	15%	0%	0%	83%
Dust	0%	0%	53%	21%	0%	0%	0%
Fires	30%	3%	12%	35%	3%	9%	9%
Fuel Combustion: Commercial/Residential	4%	4%	2%	7%	4%	1%	2%
Fuel Combustion: Electric Generation	1%	14%	1%	3%	71%	0%	1%
Fuel Combustion: Industrial Fuel	1%	7%	1%	3%	9%	0%	0%
Fuel Combustion: Mobile Sources	53%	58%	3%	7%	2%	8%	3%
Industrial Processes	3%	8%	4%	5%	10%	6%	2%
Other	10%	7%	1%	4%	0%	76%	1%

Source: **2014 National Emissions Inventory**

Table 2. Breakdown of Fuel Combustion-Related Criteria Air Pollutants by Fuel

	CO	NO_x	PM10	PM25	SO_2	VOC	NH_3
Biomass	6%	1%	36%	43%	1%	8%	10%
Coal	1%	15%	18%	15%	89%	1%	4%
Natural Gas	1%	10%	4%	5%	0%	2%	26%
Oil (non-mobile)	0%	2%	2%	2%	6%	0%	2%
On- and Off-Road Diesel	4%	31%	18%	19%	0%	7%	3%
On- and Off-Road Non-Diesel	84%	27%	17%	10%	1%	80%	52%
Other (mobile)	3%	12%	4%	5%	2%	2%	1%
Other (non-mobile)	1%	1%	2%	2%	2%	0%	2%

Source: **2014 National Emissions Inventory**

And these estimated benefits did not account for the health benefits from reductions in CO, PM10, VOCs, and NH_3 or the non-PM2.5 benefits from reduced NO_x (which is a precursor to ozone pollution) or SO_2 (which contributes to acid rain). If these benefits could be measured and incorporated, it is likely that the health benefits of carbon pricing policies would be much higher.

A higher carbon price (all of the current **carbon fee proposals** have higher price paths) would further reduce fuel combustion and provide greater health benefits through cleaner air.

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