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Representing the Reduction of Diesel Particulate Matter Emissions as a Reduction in CO_2 Equivalent Emissions

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Impact of Diesel Particulate Matter on Climate Change

While the health impacts of diesel particulate matter (DPM) have been well documented for years, understanding the exact impact of particulate matter on climate change can be challenging due to several factors. While the global warming potential of the seven gases included in the Kyoto Protocol, CO_2, CH_4, N_20, HFCs, PFCs, SF_6 and NF_3, are well established, diesel particulate matter is a blend of multiple components, each having a different global warming potential. These components have a climate impact when they are airborne and potentially a different climate impact when they settle out of the air.

Diesel particulate matter emissions are accurately described as a short-lived climate super pollutant when compared to CO_2 itself, because airborne diesel particulates deliver an intense, almost immediate jolt of climate warming heat to the atmosphere, which can only be equaled by a vastly greater amount of CO_2 acting over many decades. To meaningfully compare the effects of diesel particulate matter emissions to those of greenhouse gases, an understanding of 20-year versus 100-year global warming potential is required. While complex, the challenge of establishing a global warming potential for diesel particulate matter has been studied over the past several decades, and a reasonable estimate can be made. Reduction of diesel particulate matter emissions is a critical parallel path to decarbonization and can help prevent a multitude of climate tipping points that could accelerate global temperature rise and its negative impact on society.

Negative Health Impacts of Diesel Particulate Matter

Short-term and chronic exposure to particulate matter can have significant negative health consequences for communities surrounding distribution centers, rail yards, ports, and other concentrations of diesel engine operation, as well as the employees working in and around those concentrations. Fine particulate matter (PM2.5) air pollution deserves special consideration, as it is responsible for 63% of deaths from environmental causes and 3% of death from all causes.[1] The largest component of diesel particulate matter, black carbon, is a known carcinogen and causes strokes, heart attacks and chronic respiratory disease.[2] Even low levels of particulate matter in 2 to 4 year olds causes behavior issues and lower IQ scores.[3] Having clean air to breathe is a key social determinate of health and should be treated as importantly as access to education, healthy foods, employment and shelter.

Global Warming Potential Timeframe

According to the U.S. Environmental Protection Agency, “Greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's warming. Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere.”[4]

The Global Warming Potential (GWP) was developed to enable comparisons of how different gases impact global warming. GWPs provide a common unit of measure, CO_2 equivalent or CO_2e, which allows analysts to add up emissions estimates of different gases. CO_2, by

definition, has a GWP of 1, regardless of the time period used, because it is the gas being used as the reference.

Academic research often uses a 100-year time horizon to calculate GWP (known as "GWP100"), meaning that the accumulated effect of a climate-warming emission is added up over 100 years and compared to the effect of the same mass of CO_2 over 100 years. This approach does not adjust for the fact that, unlike CO_2, diesel particulates and other short-lived climate pollutants (SLCPs) are present in the atmosphere and able to cause warming only for a tiny fraction of the 100-year time horizon, less than two weeks in the case of diesel particulate emissions. In other words, GWP100 compares the impact of diesel particulates over two weeks to that of CO_2 over 100 years. GWP100 thereby tends to disguise the fact that diesel particulates and other SLCPs are far more potent contributors to global warming, per kilogram, than CO_2.

CO_2 remains in the climate system for a very long time, between 300 to 1000 years. In contrast, there are several short-lived climate pollutants of which impact on climate warming is significant, but their lifespan in the climate system is short-lived. Using GWP100 thus underestimates the negative impact of these SLCPs and therefore underrepresents their impact on short-term warming. This white paper will use a time horizon of 20 years (GWP20) instead of 100 years to more accurately represent the potency of SLCPs as climate-warming agents. Reducing short-lived climate pollutants can play a substantial, immediate role in limiting global warming and preventing multiple climate tipping points that make avoiding climate catastrophes difficult, including melting polar ice caps, dieback of forests, and the collapse of coral reefs. Reducing SLCP emissions buys precious time to find long-term, sustainable solutions to avoid the greatest negative consequences of climate change.

Components of Diesel Particulate Matter and Their Respective Global Warming Potentials

Diesel particulate matter is made up of black carbon, or soot, in addition to many organic compounds. Diesel exhaust also contains gaseous pollutants including volatile organic compounds (VOCs) and NOx. NOx emissions from diesel engines are important because they can undergo chemical reactions in the atmosphere leading to formation of particulate matter and ozone. Diesel exhaust also contains CO_2. Based on the Intergovernmental Panel on Climate Change (IPCC) guidelines, 3.2 kg of diesel fuel (about one gallon) will produce around 10 kg of CO_2.[5] While exhaust treatment can reduce particulate matter and NOx emissions from diesel engines, the only way to directly reduce CO_2 emissions is through improved fuel efficiency and running the diesel engine less through idle reduction, electric standby and optimized logistics.

The GWP20 of diesel particulate matter emissions can be estimated as the mass-weighted average of the GWP20 values of its principal components, black carbon (BC) and organic carbon (OC). For simplicity, we assume that black carbon generally comprises 75% of diesel particulate matter emissions by mass and organic carbon comprises the remaining 25%.[6] This white paper uses values for the GWP20 of black carbon (BC GWP20 = 2200) and organic carbon (OC GWP = -250) that the Clean Air Task Force (CATF) considers to be best estimates.[7] Black carbon is dark and therefore a light-absorptive heat sink, whereas organic

carbon particles are typically reflective and serve to cool the atmosphere. This difference explains the negative GWP estimate for organic carbon. The weighted average estimate of GWP20 for diesel particulate matter is calculated using the CATF estimates as follows.

(BC GWP x 75%) + (OC GWP x 25%) = DPM GWP

(2200 x 0.75) + ((-250) x 0.25) = DPM GWP

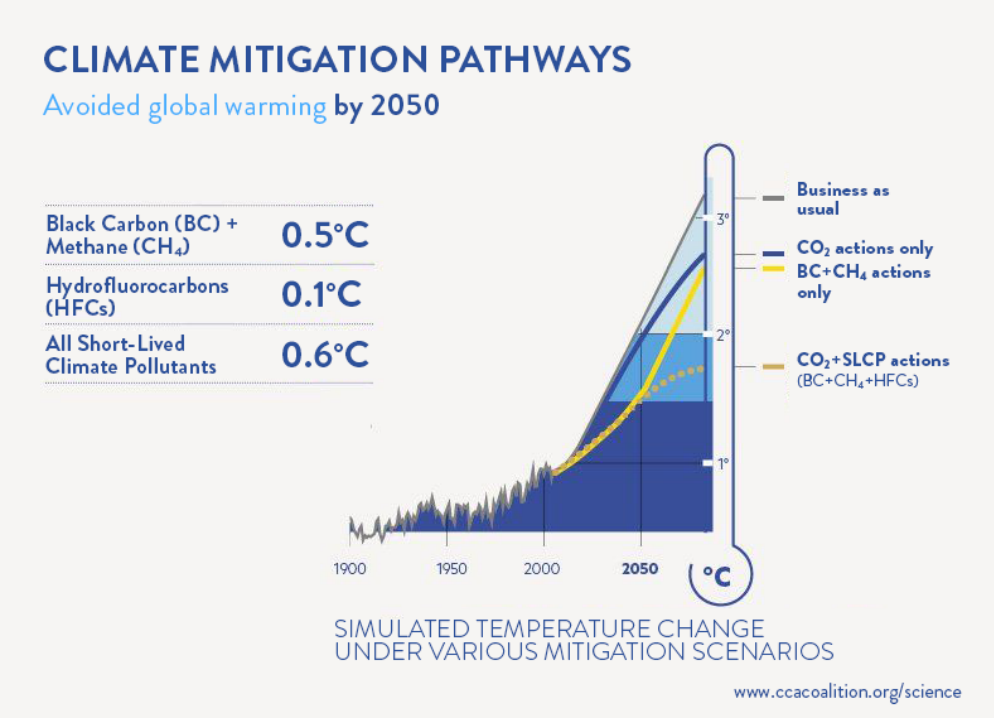
1650 + (-62.5) = 1588

The result that DPM has a GWP20 of 1588 means that just 1 gram of PM, during its less than two-week lifetime in the atmosphere adds as much global warming heat as 1588 grams of CO_2 does over a period of 20 years in the atmosphere.

Importance of Focusing on Short-lived Climate Pollutants

SLCPs such as black carbon (found in DPM) and methane have an important role to play in avoiding the worst outcomes of global warming. While action needs to be taken today to reduce CO_2 emissions, the effect of those actions will take many years to be seen, while a reduction in SLCP emissions becomes equivalent to a negative sustained rate of emission of CO_2e.[8] Without focusing on both CO_2 and SLCP, we cannot prevent the climate from exceeding the limits set by the Paris Agreement. As stated by Melissa Denchak in her 2021 article on the Natural Resources Defense Council website, “The agreement aims to substantially reduce global greenhouse gas emissions in an effort to limit the global temperature increase in this century to 2 degrees Celsius above preindustrial levels, while pursuing the means to limit the increase to 1.5 degrees.”[9]

Figure 1 Climate mitigation pathways to avoid global warming by 2050, Source: Climate & Clean Air Coalition [10]



Conclusion

Recent studies cited in the IPCC report estimate that emissions of black carbon are the second largest contributor to global warming, after carbon dioxide emissions.[2] The importance of accounting for the total global warming impact of diesel emissions to include the direct emission of CO_2 in addition to the impact of particulate matter is critical. Many producers, shippers and retailers develop science-based target initiatives centered on a reduction of CO_2e, and a complete accounting of emissions and impact must be considered to allow prioritization of sustainability projects. While not perfect, converting SLCP emissions to CO_2e allows for improved decision making and ultimately improved air quality and health outcomes. By addressing local pollution, we are addressing global climate change and minimizing the worst climate outcomes.

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