COMBATING BLACK CARBON FOR CLEAN AIR AND CLIMATE

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Centre for Science and Environment

Contents

1. The spotlight

The incoming Presidency of the upcoming United Nations Framework Convention on Climate Change (UNFCCC) at the 28th Conference of Parties (COP 28) in Dubai this year has in its communication to the parties sought "four paradigm shifts" for transformative action. These include fast tracking the energy transition and reducing emissions before 2030; transforming climate finance to deliver on old promises and setting the framework for a new deal on finance; putting people, nature, lives and livelihoods at the heart of climate action and mobilizing for the most inclusive COP ever.[1]

This is not only an opportunity to strengthen the global deal for effective mitigation of carbon dioxide (CO_2) emissions to be consistent with the global pathway for stabilizing global temperature below 1.5 degree Celsius (°C), but is also an opportunity to maximize welfare, public health and sustainable development gains by reducing a range of harmful pollutants that are also co-emitted and are climate rogues.

The Intergovernmental Panel on Climate Change (IPCC) has recognized that to meet the global climate goals, rapid mitigation of all climate forcing emissions are necessary. These include the short-lived climate pollutants (SLCP) that as local air pollutants are extremely harmful and can also substantially affect the climate system in the short term as they have higher global warming potential. But they have shorter atmospheric lifetime than heat-trapping long-lived carbon dioxide (CO_2). SLCPs include local pollutants such as black carbon and tropospheric ozone as well as heat-trapping methane and hydrofluorocarbons.

Both the Fifth and Sixth Assessment Reports (AR5 and AR6) of IPCC on climate change mitigation have highlighted the science of warming impacts of SLCPs, underscoring the importance of their mitigation.[2] This has broken the silos of air pollution and climate change action.

However, the SLCPs are not in the basket of climate change agents under the climate convention or an agenda item under the UNFCCC. But there is a strong interest in parallel action to leverage the global progress towards net-zero CO_2 by mid-century to also deliver on SLCP reduction. Both CO_2 and SLCPs are co-emitted by a widely diverse set of emissions sources and therefore co-control is a significant opportunity to maximize public health gains, climate change mitigation and climate resilience.

The World Health Organization (WHO) in the meantime has also sought convergence of climate and clean air action to address air pollutants that not only severely impact public health, but also the earth's climate and ecosystems.[3] They contribute to both climate change and ill health.

The global community has already brought to focus the agenda of SLCPs and initiated multi-stakeholders discussion alongside the COP process. At COP 27 in 2022, the Climate and Clean Air Coalition (CCAC) had convened more than 40 member countries along with intergovernmental organizations, businesses, scientific institutions and civil society organizations to emphasize the intrinsic linkage between air pollution and climate change to maximize environmental and health benefits.

Earlier, in COP 26 in Glasgow, WHO's policy brief and communiqué had stated that globally, comprehensive mitigation measures targeting SLCPs could cut the rate of global warming in half (a 0.6°C reduction) while helping prevent 7 million premature deaths from outdoor and household air pollution annually. This can also prevent 52 million tonnes of crop losses annually by 2030. The health effects of air pollution had a global cost of US $8.1 trillion in 2019, equivalent to 6.1 per cent of global GDP for that year.[4]

The CCAC ministerial communiqués at COP 27 had taken that further to state that as a complement to scaled-up action on CO_2, SLCP emissions reduction while avoiding 0.6°C of predicted global warming in the near term can also slow down sea-level rise by 20 per cent, the rate of Arctic warming by up to two-thirds and the rate of global warming by half by mid-century.[5]

Clean air benefits from climate action is evident from the IPCC's AR6 report, which shows if climate policies align with the Copenhagen pledges and a long-term CO_2 target of 450 ppm, the share of the global population exposed to PM2.5 levels above the WHO Tier 1 standard of 35 $\mu g\ m^3$ can reduce from 21 per cent to 5 per cent in 2030.

It is encouraging that a number of countries have begun to include air pollution and SLCPs in their Nationally Determined Commitments (NDCs). According to WHO's policy brief in COP 26, inclusion of air pollution in NDCs has more than doubled (from 16 to 47) from the first round of submissions starting in 2015 to the updates submitted since 2020. The climate targets and NDCs are due to be updated in 2025. Thus, influencing the next round of revision of NDCs by the countries will be critical and valuable.

Against this backdrop, COP 28 presents an enormous opportunity to deepen the interface between climate and clean air action at the global and national scales.

Experts have however cautioned that the "policy community should be careful not to trade action on black carbon for action on carbon dioxide. Both produce positive radiative forcing that cause climate change and action on both is necessary to reduce this to achieve climate goals."[6] This has emerged from the global convening of the International Council on Clean Transportation and the leading experts about a decade ago.

Action on the most positive radiative forcing and on policies that can simultaneously reduce SLCPs and CO_2 needs to be prioritized. It is also needed to ensure that the burden of climate change mitigation is not shifting disproportionately to the developing South. While reducing all positive radiative forcing, action to reduce carbon dioxide, the largest positive forcing agent, cannot be delayed to maximize welfare gains from global climate action.

This conversation has to get stronger as the Global South is battling a severe air pollution problem with serious public health consequences and also have to be on low carbon pathways. Countries in Asia, particularly South Asia and Africa, are deeply affected by toxic air and are ramping up action to mitigate to be able to meet the clean air benchmark and protect public health goals. Therefore, the clean air and low carbon pathways have to converge and that needs to be enabled.

2. Decoding black carbon

What is black carbon? The IPCC has long recognized methane, nitrous oxide and hydrofluorocarbons as greenhouse gases, but in the mid-2000s it also included black carbon, which is a product of low temperature incomplete combustion of carbonaceous fuels.

Black carbon is the solid carbonaceous fraction of particulate matter of less than 10 micrometre size (PM10) or less than 2.5 micrometre (PM2.5), which strongly absorbs light and converts that energy to heat. PM2.5 harms the global population who breathe air that does not meet the WHO air quality guidelines.

Black carbon is short-lived, lasting up to minutes, hours, a week or a little more in the atmosphere. In contrast, CO_2 emitted today can impact future climate for 30 to over 100 years.

Black carbon is emitted from combustion processes, dust-generating activities and secondary particulates (nitrates, sulphates etc.). The composition of black carbon varies with the type of fuel used, combustion process, and emission control technologies or practices. IPCC's AR6 report provides details on a range of impacts of black carbon, including warming, snow melt and effect on precipitation, among others.

Black carbon and warming: As per the literature, black carbon absorbs light, converts it into heat and warms up the surrounding atmosphere. Scientists calculate the potential to cause global warming in terms of "radiative forcing", which is the difference of sunlight absorbed and energy radiated back in watts per square metre of surface.

The IPCC AR5 report, while quantifying the warming potential of each pollutant, stated that black carbon can be 900 times more warming than CO_2 in a 20-year time horizon. The IPCC estimates of radiative forcing are said to be conservative compared to the others in the published literature. Nonetheless, SLCPs such as black carbon absorb substantially more heat than CO_2 to spike the global warming curve in the near term.

As emissions and concentration of black carbon is not uniform across all regions, their effect is also more regional compared to the global impact of the more ubiquitous CO_2. As long as they are in the atmosphere their effects on the climate can be strong.

Scientists point out that there is uncertainty in the emission metrics such as Global Warming Potential (GWP) and Global Temperature Change Potential (GTP) of black carbon and its potential to cause climate change. This may lead to variability in quantification of effects of black carbon on climate systems in different regions of the world. But overall, its impacts are undeniable.

Black carbon and snowmelt: Black carbon can also accelerate ice melt when it settles on snow. Bright snow surfaces reflect a high amount of solar energy back into space. But black carbon absorbs a substantial fraction of this energy and re-emits it as heat. The Arctic and the Himalayas are therefore hugely vulnerable. Black carbon on glacial snow can alter the melt cycle of glaciers and affect the water balance and water supply through seasons. These regional impacts affected by the local trend of pollution and movement of pollution are a matter of concern.

Black carbon and rains: Black carbon is also known to interfere with cloud formation and rainfall patterns, and may change precipitation and surface visibility. Scientists explain that emissions can suppress convection and stabilize the atmosphere in ways that may impede normal precipitation patterns. Scientists describe this as dimming of the earth's surface, which reduces patterns of evaporation that make clouds. If black carbon heats up the layer of the atmosphere where clouds are forming, for example, the clouds will evaporate.

Not being able to reflect sunlight back into space, soot-laced clouds end up warming the atmosphere. But black carbon that hangs above low-lying clouds stabilizes the layer of air on top of the clouds, promoting their growth. These clouds, like shields, block incoming sunlight. As a result, black carbon also ends up cooling the planet. There are now several studies and evidence that provide insight into varied impacts of black carbon.

Regional and transboundary impacts and manifestations: Regional level-impacts on cloud formation, rainfall pattern and weather, snow melt and water systems can be high and varied. As IPCC AR6 points out, in the northern hemisphere black carbon is likely to lead to early springtime snow melt but the magnitude is uncertain. In South Asia, absorbing particles may be influencing precipitation patterns. In the Tibetan Plateau it may cause changes in circulation and darkening of snow and contribute towards glacier melting, though the magnitude is not clear. All these effects will require locally appropriate action.

The US-based Scripps Institution of Oceanography has further pointed towards transboundary movement of black carbon on the basis of aircraft-based studies and modelling. It finds that as altitude increases, the fraction of total black carbon that originates in Asia also increases. When pollution reaches the boundary layer, it becomes stable and travels long distances. At ground level, black carbon is more from local sources.

3. Why black carbon and CO_2 need aligned mitigation

Warming versus cooling: There is also a complex chemistry behind the warming and cooling effects of the aerosols. All particles do not warm. Emissions sources that have the lowest ratio of light reflecting or cooling particles in relation to black carbon have the highest positive forcing. The opposite scenario has a more cooling effect. Sulphate, nitrate and organic aerosols cool down the climate by reflecting away the sunlight. But black carbon is light absorbing.

Thus, scientists explain, the extent of warming depends on the mix of warming and cooling aerosols, their optical properties and their lifetime. If the ratio of cooling particles is higher, sources may have a more cooling effect. For example, residential biofuel burning or high-sulphur fuels and open burning can have a cooling effect. But low-sulphur fuels cause net-positive radiative forcing. But both—if they settle on ice—can accelerate ice melting.[7]

Science is still trying to figure out this threshold for different sources. The exact threshold from negative to positive forcing for the major sources is the focus of ongoing research.

Unmasking of committed warming from CO_2: Yet another complexity is that if air pollution is controlled and cooling aerosols are removed, it can also unmask the committed warming from CO_2 and increase global temperature. The IPCC AR6 report cites studies to show that removal of sulphur dioxide (SO_2) emissions that form cooling sulphate can increase global mean surface temperature by 0.69°C. But heat-trapping black carbon reduction can reduce temperature by 0.022°C during 2041–50. But this trade-off can be small if significant CO_2 reductions are also achieved simultaneously.

Veerabhadra Ramanathan of the Scripps Institution of Oceanography, University of California, San Diego, has shown how cooling effect of aerosols "mask" the warming impact of CO_2 concentration in the atmosphere, and cites the IPCC-AR4 value which shows the masking is 40 per cent[8] of the committed warming from the current concentration of CO_2. This is not showing up as it is masked by the cooling particles such as sulphates. Unmasking of committed warming can also hasten the tipping points in different regions.

Warm or cool—all particles must go: The science of cooling and warming particles must not be interpreted to rely on the cooling effect of the aerosols. If lives of people and public health need to be safeguarded, all particles—cooling and warming particles—need to be eliminated. Cooling particles from the biomass-based cookstoves have dangerous health impacts on the poor and need to be replaced with clean fuels to save lives and the climate.

This also requires even harder action on CO_2 mitigation. Studies have established that the controls needed to reduce black carbon such as those in vehicles, are enabled by the same policies that target to reduce sulphur emissions. This underscores the importance of controlling both SLCPs and CO_2 simultaneously.

Strong clean air action that is urgently needed will remove both cooling and warming particles and unmask the committed warming of CO_2 more aggressively. Thus, co-control of SLCPs and CO_2 is necessary.

New warning against unmasking of committed warming: James Hansen, noted climate scientist, in his recent communiqué in October 2023 warned that more aggressive action to reduce particulate pollution globally to protect public health is leading to an unmasking effect.[9] This could be one of the contributory factors to the new heat extremes experienced around the world this year.

James Hansen writes, “Although it is difficult to predict future aerosol climate forcing, we expect a continual decline of the aerosol effect because of desire to reduce particulate air pollution, which causes several million deaths per year. Much of the aerosol pollution arises from fossil fuels, so, as the world moves to clean energies, aerosol amounts should decline and unmask the GHG warming that had been compensated by aerosol cooling”. [10]

Hansen concludes, “instead of aerosols reducing the rate of global warming, aerosol changes now should be adding to global warming”. [11] This combined with the fact that with more imbalances in the earth’s energy likely in the future, global warming rate will accelerate.

While action on CO_2 has to get more aggressive to counter the unmasking effect, further reduction in heat-trapping black carbon emission sources such as diesel transport needs to happen simultaneously.

4. Double burden of the developing South

While advanced economies are locked in a carbon-intensive growth model and require accelerated energy transition to curb long lived CO_2, the developing South is locked in polluting pathways that are increasing SLCP emissions enhancing local public health risks while energy intensity of growth is also increasing.

The IPCC AR6 states that on a long-term basis, aerosols have slowed down due to improvement in air quality in many parts of the world. But it has increased by more than a factor of two in Asia and is increasing in South Asia. This demands co-control of local air pollutants and greenhouse gas emissions at the early stages of growth.

It is also necessary to acknowledge that not only does air pollution contribute to warming, CO_2-triggered global warming can also worsen air pollution and public health risks. According to IPCC AR6, climate change can also induce changes in meteorological conditions; effect chemical changes that influence SLCPs' lifetime and biological changes, affecting their natural emissions; and change rainfall patterns that influence their concentration.

Climate change will further affect atmospheric concentration and chemical composition of particulate matter. With warmer climate and increase in temperatures, the reaction rate of gases will increase to convert to sulphate particles or ammonium nitrate and add to particulate concentration. Studies by Mark Jacobson have shown how with each degree of warming impacts, secondary particles and ozone increase, affecting the public-health risks. Climate change will also affect dust concentration and increase forest fires, impacting aerosols. Changing rainfall patterns will affect the wet removal process of particulate matter. This is the double burden.

Therefore, co-control of SLCP and CO_2 from the new growth in the Global South will have to be enabled and supported to fast track change.

5. Curb black carbon: Multi-sector agenda

Black carbon is emitted by vehicles (largely diesel vehicles), industrial production, household use of solid fuels, agricultural biomass and waste burning. Some of the older global black-carbon emissions inventories estimated by the climate scientist Tami Bond about a decade ago, show that the highest contributor of black carbon was biomass burning, at 37 per cent, followed by transport (both on-road and non-road transport) at 25 per cent, residential biofuels at 18 per cent and industry at 11 per cent. The rest are residential biomass and coal.[12] Relative positions of these sources and their contribution may have changed with technology improvement but these remain the principal sources of black carbon. These require accelerated mitigation.

Clean air and public health action can be a catalyst: Clean air action to meet the clean air benchmark will be the biggest driver of change to address black carbon. Regulatory and legal framework for air quality management needs to get stronger with a strong compliance mechanism for time-bound improvement in air quality. Domestic policies are already being driven by these considerations in many parts of global South. But stronger impetus can accelerate change for targeted reduction in black carbon emissions from the key sources.

Diesel black carbon: Some of the early evidence on diesel and petrol emissions characterization shows much higher share of black carbon fraction in finer particulate emitted from diesel vehicles than petrol vehicles and more in pre-Euro VI vintage.[13] Recent advancement in emissions control systems such as catalysed diesel particulate trap are expected to lower these emissions substantially. But use of these technologies are still not widespread in the developing markets. Fuel pricing policy to keep the prices of diesel cheaper, weak emissions standards and dumping of older and used vehicles, especially diesel vehicles, in some of the markets of Africa and Asia are locking in enormous black carbon emissions.

The warming potential of black carbon emissions negates the marginally higher CO_2 benefits from the relatively more fuel-efficient diesel vehicles. This benefit gets negated not only because of enhanced health risks from toxic diesel emissions, but also from the warming impacts of diesel black carbon emissions. According to an assessment carried out by Mark Z Jacobson of Stanford University, even under

Euro IV particle standards (that a large part of developing countries are aiming to meet), diesel vehicles may still warm the climate for well over the next 100 years.[14] A great part of developing-country markets are either at the Euro 4 level or below.

Countries are at different stages of motorization, dieselization and emissions standards roadmaps. Technology forcing emissions standards need to quickly phase in diesel particulate filters and low-sulphur fuels and early scrappage of high-polluting older vehicles globally.

Advanced economies have begun to set targets for phase-out of internal combustion engines and to meet ambitious targets for fleet electrification.

India, one of the major vehicle-producing countries, has taken the lead to leapfrog to Euro 6 equivalent emissions standards and skip Euro 5 in three years and is moving towards Euro 7 emissions standards combined with fleet-electrification strategy. Likewise, countries in the developing South need rapid upward harmonization of improved emissions standards.

Vehicle importing countries in the developing South on the other hand, need to link improved emissions standards and fuel economy standards with import of vehicles and also cap the age. Such efforts have begun in South Asia and Africa. Simultaneously, fuel taxation and economic instruments are needed to disincentivize use of diesel cars. Interestingly, it is Nigeria's fuel pricing policy that keeps diesel prices higher than gasoline prices and discouraged dieselization of the car fleet. With developed economies phasing out diesel cars, they may find their way to African and Asian markets. This requires reforms in both import and export policies of the trading partners to prevent such dumping. The United Nations Environment Programme (UNEP) is working with importing as well as exporting countries to upscale solutions.

City-level action will also be critical to create bottom up pressure to catalyse change. Delhi, capital city of India, illustrates this point. Following a series of Supreme Court directives and government action, Delhi has successfully reduced toxic diesel emissions over time by moving entire public transport and local commercial transport to compressed natural gas, restricting truck entry, imposing pollution charge on trucks, big diesel cars and SUVs and on diesel fuel, while leapfrogging to BS 6 emission standard in 2020. Simultaneously, it has phased out 15-year-old commercial vehicles and restricted use of more than 10-year-old diesel vehicles, including personal vehicles. As a result of these concentrated efforts to discourage use of diesel vehicles, the overall share of transport diesel consumption has reduced by 46 per cent in the city between 2014 and 2022.[15] Additionally, the overall share of diesel car registration in total car registration has reduced significantly from more than 35 per cent in 2014–15 to 7.5 per cent in 2022–23.[16]

There is also an opportunity for rapid electrification of the new vehicle fleet in the markets of developing South. There are encouraging signs of southern governments showing interest in leveraging electrification programme as an industry policy. Simplicity of this technology compared to internal combustion engines supports this transition. While vehicle producing countries like India have set in motion wide ranging incentive programme and production linked incentives to build the market and local manufacturing base, importing countries in Africa and South Asia have also initiated process for scaling up local assembly and incentivize market development. This needs to be enabled and supported to accelerate the transition.

Black carbon mitigation from the transport sector will also require mobility strategy, vehicle restraint measures, and investments in infrastructure to promote mass transit, bicycling, walking and telecommuting. Land use and urban planning need to make cities more transit oriented, bring jobs and people closer to transit lines, promote mix land use and mixed income development near transit nodes, develop people friendly high street density and prevent sprawl.

Equally strong attention needs to be given to off-road transportation, including marine shipping, locomotives, agricultural vehicles and, construction equipment, among others, in the developing South. This will require clean and low-sulphur fuels and emissions control technologies and in some cases electrification.

Household fuels: Exposure to household air pollution is most widespread in sub-Saharan Africa and in parts of Asia. Addressing this requires a massive transition in cooking energy. Even though progress has been noted globally in reducing household exposure, the problem is still very large given the level of poverty and inadequate access to clean energy. According to the *State of Global Air 2020*, there is a reduction in global average in the percentage of population exposed to household air pollution from 2010 to 2019.

However, the level of progress varies across countries. More progress has been noted in countries in South and East Asia due to more aggressive measures to switch to cleaner fuels. It is still a challenge in several countries in Africa, where growing populations are leading to higher exposures from solid fuels for cooking. Also in several countries in Asia and Africa, sustained use of clean fuels in poor households is not always economically feasible. This often leads to sliding back to mixed fuels use.

These emerging economies provide an opportunity to leapfrog by moving to cleaner cooking energy. This transition away from dirty cooking fuel to cleaner energy on the energy ladder, including cooking gas to induction cooking on clean electricity—from biomass gasification to solar energy—has huge health benefits and must be supported.

Countries like India have stepped up distribution of liquefied petroleum gas (LPG) and improved access of the households to cleaner fuels. According to the State of Global Air 2019, India has reduced its proportion of households cooking with solid fuels from 76 per cent in 2005 to 60 per cent in 2017 due to the government programme to shift households from solid fuels to LPG. However, this now needs more innovative action people are often too poor to afford sustained use of LPG and often fall back on solid fuels or mixed fuel use. This will have to be addressed through more effective design of economic instruments. Also more LPG should be freed up for poor households by shifting the higher income groups to electricity for induction cooking. Studies in India have shown that curbing household pollution can help India to meet the interim targets of WHO. [17]

Clean industry strategy: Emissions of black carbon from industrial sources are not very well characterized though it is now widely accepted that the dominance of small- and medium-scale units, especially brick kilns, in the developing South are the primary emitters of black carbon. Diesel generator sets that are widely used for captive electricity generation are also a cause of concern and will have to be addressed with reliable access to clean electricity from the grid and decentralized renewable energy systems.

Brick kilns are widely dispersed sources that are also difficult to monitor and will have to be pushed with alternative and improved kiln technologies and emissions control systems and use of clean fuels. Given the fact that small- and medium-scale units dominate the economy of the Global South, inventorizing and characterizing fuel use, combustion technologies and emissions profile across industry segments will be crucial for mitigation action. This is a big challenge in South Asia.

Open burning and forest fires: Seasonal crop burning and forest fires are a high emitter of organic carbon. It is quite likely that they have a cooling effect. But their emissions near snow and ice can have strong regional warming and melting effects. Nearly all regions are vulnerable to forest fires due to rising heat index and warming. Forest management, including fire control practices, needs to improve. This requires locally appropriate strategies.

Strategies are needed also to stop seasonal crop residue burning, which is quite widespread in Asia, with efforts to mulch residues and find alternative ex-situ uses of crop waste. Industrial use of crop waste as biomass fuel, for power generation, bio CNG, or to produce a range of consumer products, can create economic value for the farmers and the required incentive to discourage burning.

Additionally, burning of municipal solid waste is a serious challenge in many parts of developing South. This is also one of the key contributor to yet another SLCP, methane. This needs a strong circularity policy to close the loop around all waste streams for material recovery and remediation of legacy waste.

Address other dispersed non-road sources like shipping that have transboundary effect: Even though the developed North has reduced local pollution from on-road transportation considerably, non-road transport like shipping that still use dirty and heavy fuels contribute substantially to global black carbon emissions. This requires global action for accelerated mitigation.

6. COP 28 agenda: Need a global action for maximum co-benefits and equitable strategy

The upcoming COP 28 is an opportunity to garner global support for this co-benefit framework and accelerate global cooperation to enable and strengthen national action on SLCPs including black carbon. The UN Environment Programme (UNEP) has already convened the Climate and Clean Air Coalition with support from other global agencies and multilateral bodies that have membership of a large number of countries for joint action on SLCPs.

WHO has further underscored the importance of this linkage and action. This effort requires a more effective interface with the UNFCCC process for comprehensive mitigation measures to maximize air quality, public health and welfare gains while fast tracking CO_2 reduction and building climate resilience. Focus on priority action at the COP 28 and beyond should be built.

Mobilize stakeholders for global and regional cooperation framework for stronger support to sectoral policies and action on SLCPs in the global South. Countries are already shaping their clean air and climate programmes, policies and implementation strategies to meet clean air targets. Interlinking the learning from these programmes at local and global level and strategic support can have a multiplier effect.

A growing number of countries have started to include air pollution in their reporting on nationally determined commitment (NDC) to the UNFCCC and will revise NDCs in 2025. This needs to include assessment of public-health benefits and low-carbon gains. Countries that are reporting on clean air action to capture the learning curve and promote cross learning must be engaged and convened.

Several global platforms and forums have been established alongside the COP process for more advanced action in several sectoral areas, including clean energy transition, clean cooking, and zero emissions vehicle (ZEV) transition that can be leveraged to accelerate SLCP action in different regions. Synergy

should be built and leveraged with these global platforms to influence and inform their convening, agenda and convergence of issues in COP 28. Some of these platforms include the Declaration on 100 per cent transition to zero emissions by 2030–2040, and the ZEV Transition Council, which represents 50 per cent of the global car market. There is also a Solar Alliance, among others.

Global and national networks should be convened to sensitize them about SLCPs and the linkage between clean air and climate action and cross learning should be promoted. This can support local action in the global South with science, good data and best practice approaches. There is considerable opportunity in the early stages of motorization and industrialization to be preventive and avoid pollution-intensive pathways.

Engagement to influence global climate finance mechanism must be built and additional finance including bilateral and multilateral funding need to be unlocked and mainstreamed with appropriate indicators to assess the co-benefit outcomes from the investments.

Campaigns to improve public visibility of these issues must be designed and public and policy understanding of science, policy and action related to SLCPs deepened to help build the new narrative. This requires creative communication on good practices and innovations, to influence opinion and mobilize opinion makers and local stakeholders in different regions.

Building a global database and inventory of greenhouse gases and SLCP sources and emissions must be enabled and local institutional capability to inform action.

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Black carbon harms health, and traps heat, melts snow and disturbs rain patterns for as long as it is airborne. While long-lived carbon dioxide (CO_2) needs fast-tracked action to stabilize global temperature rise to within 1.5 degrees Celsius, black carbon needs elimination to contain short-term warming spikes and to protect public health.

Global action to reduce black carbon from sources such as diesel vehicles, brick kilns, cookstoves and ships, and co-control of CO_2 from the same sources can provide co-benefits of public-health protection and climate change mitigation. But scientists say that stronger global action on air pollution is beginning to eliminate both cooling and warming aerosols and unmasking the warming already committed from high CO_2 concentration. This can lead to new heat extremes.

An even more aggressive action on CO_2 is needed to counter the unmasking effect of air pollution control to not add to warming, while stronger black carbon emissions control can prevent millions of deaths worldwide. Adopting a global and regional cooperation framework for stronger support to sectoral action on black carbon in the global South is vital to enable clean pathways.

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